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STATE OF ILLINOIS
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MONOGRAPH 1

THE MISSISSIPPIAN BRACHIOPODA

OF THE

MISSISSIPPI VALLEY BASIN

TEXT

BY

STUART WELLER

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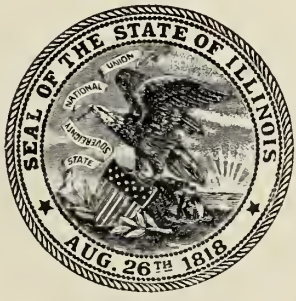

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EDWARD F. DUNNE, *Chairman*
Governor of Illinois

THOMAS C. CHAMBERLIN, *Vice-Chairman*

EDMUND J. JAMES, *Secretary*
President of the University of Illinois

FRANK W. DEWOLF, *Director*

REPORT PREPARED UNDER STATE GEOLOGICAL COMMISSION

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LETTER OF TRANSMITTAL

State Geological Survey

University of Illinois, February 15, 1913.

Governor E. F. Dunne, Chairman, and Members of the Geological Survey Commission:

Gentlemen: When the present Survey was created in 1905 the Geological Commission adopted a balanced program which emphasized economic work of immediate, though perhaps temporary, value; it nevertheless included deep scientific research into fundamental problems, having only indirect bearing on economic geology of the State.

The Survey has now published nineteen bulletins and many useful maps which have served an increasing public demand. Nine other reports are in manuscript form for early printing. I now have the pleasure of transmitting to you an illustrated report on the Mississippian Brachiopoda, by Professor Stuart Weller of the University of Chicago, and I recommend that it be published as the first of the scientific monographs of the Survey.

Because of the highly technical character of this report it is perhaps fitting to state that an understanding of our geological formations is based not only on their materials but also on their included fossil remains, which indicate the relative time-periods during which the rocks were deposited. The Mississippian formations have their type localities in Illinois and the immediately adjoining states of the Mississippi Valley. The study of these strata for more than half a century has been attended by considerable confusion. Professor Weller's work, extending over a period of eight years, has solved many of the difficulties of stratigraphy and paleontology. His monograph will be gratefully received by professional geologists throughout the world.

Very respectfully,

Frank W. DeWolf, *Director.*

PREFACE

No comprehensive study of the fossils of the Mississippian formations of Illinois and the adjacent parts of the Mississippi Valley Basin has ever been attempted. The species have been described in various publications, in state reports, in short papers in the transactions of learned societies, geological journals, etc.; many forms have never been illustrated, and many still remain undescribed. The literature on the subject is widely scattered, and most of it is not readily accessible to a large number of geological workers and students. James Hall's Report on the Paleontology of Iowa, published in 1858 and long since out of print, still remains the principal source of information to most students, concerning these faunas.

The present work is a start towards the preparation of a series of monographs which it is hoped may eventually cover all the groups of organisms whose fossil remains are preserved in these formations. The brachiopods have been selected as the first group to receive consideration because of their almost universal presence in the faunas, and because their characters are such as to make them most readily recognizable under ordinary conditions. The specimens are much more apt to be preserved in a sufficiently complete condition to allow of their identification, than are the specimens of some other groups, such as the crinoids for instance. They are much more abundant than are the species of the several classes of Mollusca, and they do not require the grinding of thin sections, as do many of the Bryozoa. Furthermore the species are almost all rather closely limited in their geological range, being characteristic for the most part, of the fauna in which they occur. The field geologist who has the means at hand to enable him to recognize the brachiopods will not have difficulty in determining the horizon of the strata he may be studying.

In the present work all the brachiopods known to occur in the formations of the standard Mississippian section of the Mississippi Valley, so far as they could be secured, have been considered. These formations have their typical development not alone in Illinois, but also in Missouri and Iowa, so that not a few of the examples studied, described, and illustrated are from localities outside of Illinois, although most of the species may be looked for in the Illinois formations. A few forms from adjacent regions, Indiana, Kentucky, Arkansas, and southwestern Missouri have been included in the discussion of the species and perhaps may never be found in any Illinois locality; the reason for their inclusion here being their relationship to Illinois species.

Under the discussion of each species the name of the geological formation or formations of whose fauna the species is a member, has been recorded, but no attempt has been made to record all the localities from which the species is known. In the explanation of the plates, however, the exact locality of the specimen illustrated has always been mentioned.

The material used in the preparation of the report has been drawn from all available sources. The collections in the Walker Museum of The University of Chicago have been a most prolific source of supply because of the presence of the Gurley collection and the James Hall collection, both of which are rich in types of Mississippian fossils, as well as of several smaller collections, of which the Sampson collection and the Van Horne collection especially have supplied important specimens. Through the kindness of Dr. A. R. Crook, curator of the Illinois State Museum of Natural History, several type specimens have been loaned for study and illustration from the collections of that institution. Dr. E. O. Hovey of the American Museum of Natural History in New York City has been most generous in his willingness to send many important type specimens to the author for study and illustration. The many types of species described by Winchell and by White and Whitfield, preserved in the White collection in the museum of the University of Michigan, have been made available for study and illustration through the co-operation of Dr. E. C. Case. Dr. R. S. Bassler has generously loaned certain material from the U. S. National Museum in Washington. Besides these curators of great public collections, private collectors have not been backward in furthering the preparation of the report. Prof. R. R. Rowley, of Louisiana, Missouri, who has described many species of Mississippian brachiopods, has generously placed in the hands of the writer either the types or authentic specimens of all his species, which have been used for the illustrations and as the basis for the definitions here published. Mr. D. K. Greger of Fulton, Missouri, has made his extensive collection of Mississippian brachiopods freely available to the writer in the preparation of the report. To all these curators and collectors I wish to express my great obligation, for without their co-operation the report could never have been made as complete as it now is.

No claim of absolute completeness can be made for any work of this sort. Many species were described entirely without illustrations by earlier workers in the subject, and in many instances the original types of these species have been lost or destroyed. It has been possible to recognize many such species from the definitions or from the definitions along with specimens more recently collected in the original localities, but there still remains a considerable number of such species which have not been recognized, some or all of which may still be cleared up through future collection and study. It is also to be expected that further work in the field may bring to light additional undescribed species.

In the preparation of the body of the report new definitions of all of the species have been written so that the usage of terms is uniform throughout. In the definitions, the usual size of the members of any species has been expressed in the relative terms large, small, etc., these terms being used on the arbitrary basis that a specimen having a diameter of about 25 mm. or 1 inch, is medium sized. Specimens smaller than this are below medium size or small, while specimens of larger dimensions are above medium size or large. Besides these general dimensions, accurate measurements of one or more specimens have always been given. The usage of the terms cast and mould is not entirely uniform among paleontological writers. In the present work the term internal cast, or cast of the interior of the shell, is applied to the hardened matrix which has filled the interior of the shell or valve, the cavity of the shell or valve being assumed to be the mould in which such a cast was formed.

All the illustrations on the accompanying plates are reproduced from photographs taken from the actual specimens. During the earlier part of the work I was materially assisted in the preparation of photographs by Mr. J. M. Jessup, and I wish here to acknowledge his very efficient aid in this part of the work.

STUART WELLER.

Chicago, September 1, 1913.

GEOLOGICAL INTRODUCTION

The Mississippian section in Illinois and the adjacent portions of the Mississippi Valley Basin constitutes the typical section of that system of strata in America. The entire series of formations is prevailingly calcareous from its base to above the middle, but the upper portion includes conspicuous sandstone strata interbedded with important shales and limestones. The name "Subcarboniferous limestone" was first used by Owen for this series of formations and was the common designation for these rocks until 1891, at which time Williams[1] proposed to subdivide the Carboniferous into the Mississippian and the Pennsylvanian, the former name being applied to the so-called Subcarboniferous rocks of earlier authors, and the latter to the series of formation which had previously been designated as Coal Measures. These two names were at once generally adopted by American geologists.

The subdivision of the entire Mississippian system, with the application of geographic formation names to the several units, in accordance with modern usage, was first accomplished by James Hall in his Iowa Report[2] in 1858, although formation names, mostly of lithological or paleontological derivation, had been applied to the several formations by earlier authors. In his study of the section Hall had as an assistant Mr. A. H. Worthen, who later became the state geologist of Illinois, and who used Hall's nomenclature, with some minor changes, in his reports on the geology and paleontology of Illinois. These names, used by Hall and by Worthen, have become standard in the typical Mississippian section, although later, more detailed and more critical studies have necessitated certain important changes in the interpretation of the section, and the introduction of additional formation names. Future studies may necessitate other changes in the classification and nomenclature of the beds.

The classification of the Mississippian system here recognized is as follows:

CLASSIFICATION OF THE MISSISSIPPIAN SYSTEM

V. Chester group.
- Clore formation.
- Palestine formation.
- Menard formation.
- Okaw formation.
- Ruma formation.
- Paint Creek formation.

1 Bull. U. S. Geol. Survey No. 80. (1891.)
2 Report on the Geological Survey of the State of Iowa, vol. 1, Pts. 1 and 2. (1858.)

Yankeetown formation.
Renault formation.
Brewerville sandstone.

IV. Ste. Genevieve limestone.

III. Meramec group.
St. Louis limestone.
Salem limestone.

II. Osage group.
Warsaw formation.
Keokuk limestone.
Burlington limestone.

I. Kinderhook group.
Containing many formations more or less local in their geographical distribution.

I. KINDERHOOK GROUP

The lowermost formations of Mississippian age, constituting the Kinderhook group, were correlated by Hall with the Chemung formation of the New York Devonian section, but they are now universally considered to be of younger age, and to constitute the initial group of formations in the Mississippian system. The Kinderhook formations are exceedingly variable in their development in different parts of the Mississippi Basin, including limestone, sandstone, and shale formations. The sections lack uniformity in any two localities separated by a considerable distance; and the faunas show much variation in the several formations and in different regions.

At the locality from which the name of the group was derived, Kinderhook, Pike County, Illinois, the following section may be seen:

SECTION AT KINDERHOOK, ILLINOIS

Osage group.
4. Burlington limestone.

Kinderhook group.	Feet
3. Thin-bedded, fine-grained limestone	6
2. Thin-bedded sandstone and sandy shales	36
1. Argillaceous and sandy shales, partly hidden	40

Another locality considered as typical by Meek and Worthen, who first used the name Kinderhook group, is that exposed in the neighborhood of Burlington, Iowa, where the following succession of beds may be studied:

SECTION AT BURLINGTON, IOWA

Osage group.
8. Burlington limestone.

Kinderhook group.	Feet
7. Soft, buff, dolomitic limestone	3-5
6. White, oolitic limestone	2-4
5. Fine-grained, yellow sandstone	6-7

	Feet
4. Compact, much-fractured, gray limestone	12-18
3. Thin band of hard, impure limestone, filled with Choncles, often associated with a thin oolitic band	½-1
2. Soft, friable, argillaceous sandstone, usually yellow, but locally harder and bluish, with a large fauna of which *Chonopectus fischeri* is the most conspicuous species. The Chonopectus sandstone	25
1. Soft, blue, argillaceous shale (exposed)	60

At Hannibal, Louisiana, and Clarksville, Missouri, the section is as follows:

SECTIONS AT MISSOURI LOCALITIES

Osage group.
4. Burlington limestone.

Kinderhook group.	Feet
3. Fine-grained, compact, buff limestone	10-15
2. "Vermicular sandstone and shale" (Hannibal sandstone)	70
1. Compact, blue-gray limestone with lithographic texture (Louisiana limestone)	60

At Hamburg, Calhoun County, Illinois, the section is similar to that at Louisiana, Missouri, except in the notable reduction in thickness of the Louisiana limestone, and the introduction of an oolitic limestone above the Louisiana. The section is as follows:

SECTION AT HAMBURG, ILLINOIS

Osage group.
5. Burlington limestone.

Kinderhook group.	Feet
4. "Vermicular sandstone and shale" (Hannibal sandstone and shale)	(?)
3. White to yellow or flesh-colored oolitic limestone, with interbedded layers of sandy shales (Hamburg oolite)	1-15
2. Brown, sandy shale	1-8
1. Compact, gray limestone with lithographic texture (Louisiana limestone)	5

In central Missouri the entire Kinderhook is represented in the Chouteau limestone, about 100 feet in thickness.

In southwestern Missouri the Kinderhook section is made up of three members, as follows:

SECTION IN SOUTHWESTERN MISSOURI

Osage group.
4. Burlington limestone.

Kinderhook group.	Feet
3. Buff-colored limestone (Pierson limestone)	30

		Feet
2.	"Vermicular" sandstone with accompanying shales (Northview sandstone), about	60
1.	Tough, bluish-gray, granular limestone (Chouteau limestone, lower part), about	20

In Jefferson County, Missouri, 25 miles below St. Louis, the Kinderhook section is as follows:

SECTION IN JEFFERSON COUNTY, MISSOURI

		Feet
Osage group.		
5.	Burlington limestone.	
Kinderhook group.		
4.	Red to green, cherty limestone, often very argillaceous, (Fern Glen formation)	30
3.	Fine-grained, yellow or brown sandstone (Bushberg sandstone)	14
2.	Sandy shale	⅓
1.	Gray or yellowish oolitic limestone (Glen Park limestone), about	1

In Union County, Illinois, in the W. ½ sec. 11, T. 12 S., R. 2 W., about 3½ miles northwest of Jonesboro, along the creek west of the M. & O. Railroad track, the Kinderhook has a very different expression from that at any of the points further north, as follows:

SECTION 3½ MILES NORTHWEST OF JONESBORO, ILLINOIS.

		Feet
Osage group.		
4.	Burlington limestone.	
Kinderhook group.		
3.	Green, brittle shale	40
2.	Impure, nodular limestone (?Rockford limestone)	1
Devonian.		
1.	Thinly laminated, black, brittle, shale, (Chattanooga shale)	

These sections will suffice to exhibit the variable character of the Kinderhook sediments. Some of the formations, as noted above, have already been given local formation names, and others will doubtless be named in the future, but in no case can any formational unit be traced continuously throughout the entire basin. In the central portion of the basin the Kinderhook sediments invariably rest unconformably upon subjacent strata, but in the more northern region, as at Burlington, Iowa, and in the more southern region, as in Union County, Illinois, it is not improbable that the sedimentation was continuous from the preceding Upper Devonian into the Kinderhook. It is believed that in early Kinderhook time two distinct basins in the Mississippi Valley were occupied by the sea, one to the north and another to the south of a land barrier, because the faunas of these

two basins are fundamentally different in composition and origin. With the progress of Kinderhook time this land barrier was gradually submerged, causing the borders of the seas upon the two sides to approach each other, until in late Kinderhook time the northern and southern seas joined, and the fauna from the southern sea spread into the northern basin, supplanting the previously existing fauna of that region.

II. OSAGE GROUP

The formations constituting the Osage group are very different from those of the Kinderhook in that they are fairly uniform in both lithological and faunal character, and can be traced through the entire Mississippi Basin. The formations commonly included in the Osage are the Burlington limestone, the Keokuk limestone, and the Warsaw formation. Ulrich,[1] however, includes the last of these formations in the superjacent Meramec group, and considers the Fern Glen formation, here placed in the Kinderhook, as a basal member of the Osage.

Burlington limestone.—The Burlington limestone takes its name from Burlington, Iowa, and the formation has its most typical development in the southeastern counties of Iowa and the adjacent portions of Illinois. Further south the formation is continuously exposed in the Mississippi River bluffs from Quincy to northern Calhoun County, and also in southern Jersey County. It has a considerable area of outcrop in the river bluffs and elsewhere in Monroe County, and still further south in Jackson and Union counties. In its typical development in southeastern Iowa, a total thickness of about 150 feet has been recorded for the formation,[2] but its thickness commonly falls short of this and in some localities is not over 100 feet. The formation is constituted mainly of limestone and chert in varying proportions. The limestone layers are conspicuously crinoidal, generally consisting of a mass of the separated column joints and plates, and are in many places remarkably pure, locally containing 98 per cent of calcium carbonate. In Iowa the uppermost 30 feet comprise the so-called Montrose chert bed, in which the limestone and chert occur in alternate horizontal bands a few inches in thickness, the chert constituting 50 per cent or more of the total mass. Elsewhere in the formation in this region the chert is less conspicuously developed, being present in occasional horizontal bands or in horizontal series of concretionary nodules. Further south the chert is not so conspicuously concentrated in the upper portion of the formation, but in many places occurs abundantly throughout the entire thickness, or elsewhere more concentrated near the base.

1 U. S. Geol. Survey, Prof. Paper, 36, p. 24 (1905); Bull. Geol. Soc. America, vol. 22, plate 29. (1911.)
2 Iowa Geol. Survey, vol. III, plate 28, opposite p. 330. (1895.)

In the Monroe County exposures, the entire thickness of the formation is made up largely of alternating thin bands of chert and limestone, the chert constituting from 50 to 80 per cent of the total mass. In Union County, the formation is more cherty below and contains thick beds of pure limestone above.

The fauna of the upper beds of the Burlington limestone is remarkably uniform throughout the entire extent of the formation, and consists largely of crinoids and brachiopods. The same species occur from Iowa to southern Illinois, and to central and southwestern Missouri. The faunas of the lower beds are more diverse in character, and in many localities contain species with Kinderhook affinities.

Keokuk limestone.—The Keokuk limestone succeeds the Burlington with perfect conformity in those sections where both formations are present, and in places it is difficult to draw a sharp line of separation. In the neighborhood of Keokuk, Iowa, where the formation is typically developed, it is about 75 feet thick, a measurement which perhaps is not exceeded elsewhere. The limestone beds of the formation are in many places more or less argillaceous and are separated by shaly layers which commonly become more and more conspicuous above, and locally, as in Monroe County, Illinois, constitute the major portion of the entire formation. These limestone beds are prevailingly bluish, while those of the Burlington are nearly white, or towards the base locally brownish, and the chert associated with the Keokuk limestone is darker than that which is commonly present in the Burlington.

The fauna of the Keokuk, like that of the Burlington, is largely made up of crinoids and brachiopods, but in addition to these there are many bryozoans in the shaly beds, and some horn corals. South of St. Louis, especially in Monroe and Randolph counties, Illinois, a limestone stratum near the very top of the formation is made up of a crowded mass of the shells of the large *Productus magnus*. A few feet above this *Productus* layer is another limestone bed just as conspicuously filled with the shells of a species of *Spirifer*. These two beds, in places quite separate, and elsewhere combined in a single layer, mark the upper limit of the Keokuk formation over a considerable area in southwestern Illinois and the adjacent portion of Missouri.

Warsaw formation.—The Warsaw formation is typically developed at Warsaw, Illinois, where it attains a thickness of approximately 40 feet,[1] the section at that locality being as follows:

1 Bull. Illinois State Geol. Survey, No. 8, p. 84 (1907).

SECTION AT WARSAW, ILLINOIS

		Feet
St. Louis limestone.		
11.	Dense, bluish, brecciated limestone	10
Salem limestone.		
10.	More or less cross-bedded limestone, yellow on weathered surfaces and granular in appearance, containing large numbers of broken bryozoans; locally replaced by a calcareous grit or sandstone	8
Warsaw formation.		
9.	Thin-bedded bluish limestone, interbedded with calcareous shales. Fossil bryozoans abundant, especially *Lioclema punctata* and *Archimedes wortheni*	18
8.	Fine blue shale	3
7.	Hard, light-colored limestone, with few poorly preserved fossils	4
6.	Fine blue shale	8
5.	Magnesian limestone with shaly bands. Fossils poorly preserved and as a rule rare, mostly bryozoans	8
Keokuk limestone.		
4.	Bluish shales with numerous geodes which are generally smaller than those in the magnesian limestone beds below	21
3.	Magnesian limestone with chert bands	3
2.	Magnesian limestone with numerous geodes. Some beds more or less shaly. Geodes more numerous in the middle part of the bed. Fossils poorly preserved and rather rare, mostly imperfect bryozoans	15
1.	Blue or gray crystalline limestone with many fossils. Thickness not known, the bed extending below river level (exposed)	15

The dominant characteristic of the Warsaw formation is the presence of bluish shale with subordinate beds of limestone, but because of the softness of the beds they are rarely well exposed at the surface. The geographical distribution of the formation follows that of the Keokuk limestone wherever the full thickness of that formation is present north of the latitude of St. Louis. The formation is well developed in the Meramec basin in the St. Louis quadrangle, but southward it is seemingly absent, allowing the superjacent Salem or Spergen limestone to rest directly upon the Keokuk formation. For example, in Monroe County, Illinois, almost the entire Keokuk formation is represented by shales, with subordinate bands of limestone, which closely simulate the Warsaw, but the upper limit of these beds is marked by a conspicuous limestone layer from one to several feet in thickness, which is crowded with specimens of a species of *Spirifer*. In the Meramec Highlands section in the St. Louis quadrangle, this same *Spirifer* bed occurs about 50 feet below the base of the Salem limestone. These intervening Warsaw beds are wanting in the Monroe County section.

In his classification of the Mississippian, Ulrich[1] has included the Warsaw with the succeeding Salem or Spergen and St. Louis limestones in the Meramec group. This grouping of the formations is not followed here because the relationship of the Warsaw is manifestly closer with the subjacent than with the superjacent formations. Lithologically there is no satisfactory basis for differentiating the Warsaw from the subjacent Keokuk, and the faunal relations of the two formations are very close. In the typical expression of the two formations the Keokuk is essentially limestone with subordinate shale beds, while the Warsaw is largely shale with subordinate limestone beds; the transition from one formation to the other being gradual, with no suggestion of an unconformity. The fauna of the Warsaw does contain an element which is closely allied to the faunas of the superjacent formation, but this fauna is notoriously a recurrent element in our Mississippian series, occurring also well down in the Keokuk, in the St. Louis quadrangle and elsewhere.[2] The absence of the Warsaw formation south of St. Louis and the contact of the Salem on the Keokuk, indicates a line of unconformity which is worthy of recognition as a line of major subdivision in the Mississippian series. Unconformable relations between the thin northern extension of the Salem and the subjacent Warsaw are also indicated at Warsaw, Illinois.[3]

III. MERAMEC GROUP

The Meramec group was established by Ulrich[1] to include the Warsaw, "Spergen" and St. Louis formations, but in the present report it is used to include the "Spergen" or Salem, and the St. Louis limestones, the Warsaw formation being excluded and incorporated in the Osage group for reasons which have already been discussed. In the older reports of the Illinois Survey, by Worthen, this series of limestones was commonly called the St. Louis group, but this name, although proposed many years before the one here used, is inadvisable because the use of the same name for a subordinate formation and for the group leads to much confusion and therefore is not good practice.

Salem limestone.[4]—The Salem limestone has its typical development in Indiana where it is the source of the well-known building stone which goes on the market as "Bedford Stone." The name Bedford limestone

1 U. S. Geol. Survey, Prof. Paper, No. 24, p. 90 (1904); U. S. Geol. Survey, Prof. Paper, No. 36, p. 24 (1905).
2 Bull. U. S. Geol. Survey, No. 438, pp. 21 and 40 (1911).
3 Bull. Ill. State Geol. Survey, No. 8, pp. 83-88 (1908).
4 Spergen limestone of Ulrich.

has been used for the formation,[1] but this name was also used much earlier and is still in use for a formation in Ohio, which prior use makes it unavailable for the formation here under consideration. In 1901 Cumings[2] proposed the name Salem limestone for the formation, and in 1904 Ulrich[3] used the name Spergen in exactly the same manner. Cumings' name clearly has priority as a formation name, and by the application of the "law of priority" his name must be adopted and is consequently used here.

This formation is represented in the section at Warsaw, Illinois, by a bed of limestone about 8 feet in thickness. It increases to the south, and from Jersey to Randolph counties, its thickness is from 100 to 160 feet. The formation is limestone, almost entirely free from chert throughout, although the beds vary greatly in lithologic character. Some beds are very pure, white limestone, in many places containing great numbers of bryozoans; some beds are oolitic, while others are decidedly dolomitic. Many years ago one of the magnesian beds was mined in Jersey and St. Clair counties for the manufacture of hydraulic cement. Towards the summit of the formation some of the beds assume lithologic characters resembling the superjacent St. Louis limestone, the transition from one formation to the other being gradual, without a distinct stratigraphic break.

The fauna of the Salem limestone has long been known as the Spergen Hill fauna, from which locality, in Indiana, it was long ago described by Hall and later beautifully illustrated by Whitfield. The fauna contains a large number of species, many of which are in many instances diminutive in form. Brachiopods and fenestelloid bryozoans are among the most conspicuous members of the fauna, in addition to which many gastropods and pelecypods are locally present, besides some corals and other forms.

St. Louis limestone.—The St. Louis formation has its typical development in St. Louis and in the Mississippi river bluffs to the north and south of that city. It is essentially limestone throughout, in some places quite free from chert, and in others with conspicuous chert beds, but nowhere represented by such extensive chert beds as are commonly present in the lower portion of the Osage group. The limestones of the formation are more or less heavy-bedded, and vary considerably in lithologic texture, but are rarely oolitic. A very characteristic phase is exhibited in beds of compact bluish-gray limestone, very brittle and breaking with a conchoidal fracture, and generally exhibiting a texture almost like that of lithographic stone. In the bluffs north of Alton the formation contains

1 21st Ann. Rep. Dept. of Geol. and Natl. Resources, Indiana, pp. 291-427 (1897).
2 Jour. Geol., vol. 9, p. 232 (1901).
3 U. S. Geol. Survey, Prof. Paper, No. 24, p. 90 (1904); Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).

some important dolomitic beds in its lower portion, but such beds are much less conspicuous further south. A peculiar topographic feature marking much of the area which is immediately underlain by the St. Louis limestone, is the remarkable abundance of sink-holes; indeed in some portions of the State the boundaries of the formation can almost be drawn by outlining the areas of sink-hole topography.

The formation has a thickness of from 30 to 40 feet in southeastern Iowa; it increases in thickness to the south, attaining a thickness of some 250 feet in the river bluffs above Alton, and is said to be 325 feet thick in the St. Louis quadrangle.[1] In Monroe and Randolph counties the thickness is not so great as that recorded in St. Louis. In southeastern Iowa the formation is largely a brecciated limestone, and in the bluffs above Alton, a similar brecciated bed about 20 feet in thickness is present near the middle of the formation. In the St. Louis quadrangle brecciated beds are present here and there at different horizons in the formation, but further south this feature has not been observed.

The fauna of the St. Louis limestone is commonly not so large nor so well preserved as that of the Salem limestone, and in many places determinable fossils cannot be secured through considerable thicknesses of strata. The most varied faunas have usually been obtained from some of the cherty beds. A species of the bryozoan genus *Cystodictya* is one of the commonest fossils of the formation, and in many places occurs in great numbers upon some of the bedding planes. The corals of the genus *Lithostrotion*, *L. canadense* and *L. proliferum*, are good index fossils, and where they occur they are as a rule present in abundance, locally almost entirely constituting beds a foot or more in thickness, but elsewhere, over considerable areas and through considerable thicknesses of strata, these corals may not be found at all.

IV. STE. GENEVIEVE LIMESTONE

Shumard[2] first differentiated the strata immediately above the St. Louis limestone, and gave to them a distinct formation name, the Ste. Genevieve limestone, although he failed to point out that the two formations were separated by a distinct line of unconformity. This unconformity has been seen best in the Mississippi River bluffs below Ste. Genevieve, Missouri, where the actual contact of the formation upon the subjacent St. Louis limestone may be observed at several localities, showing the uneven surface of the lower formation, and in places solution channels along joint planes which have been filled with the younger formation.

1 Bull. U. S. Geol. Survey, No. 438, p. 23 (1911).
2 Trans. St. Louis Acad. Sci., vol. 1, p- 406 (1857); Mo. Geol. Surv., Rept. for 1855-1871, p. 293 (1873).

In Illinois the Ste. Genevieve limestone has a notable development in the valley of Fountain Creek and its tributaries in Monroe County, and extends northward as far as Alton, where it caps the Mississippi River bluffs. Worthen included all of these beds in the upper portion of the St. Louis limestone.

The name Ste. Genevieve has been revived in recent years by Ulrich,[1] in his study of the Mississippian section in western Kentucky, where he has recognized three members of the formation, the Fredonia oolite, the Rosiclare sandstone, and the Ohara limestone. This author's criterion for the recognition of the formation seems rather to be a lithologic succession, limestone below and above with an intermediate sandstone, than any faunal characteristics. In some localities the beds referred by him to the Ohara carry a characteristically Chester faunal assemblage, while at other points the Ohara fauna lacks these Chester characteristics and is distinctly older in general complexion. Because of this uncertainty as to the correctness of Ulrich's interpretation of the Ste. Genevieve, his subordinate member or formation names, Fredonia, Rosiclare and Ohara are not adopted in this place, although in certain sections in Monroe County, Illinois, there is a sandstone stratum with limestone both above and below it in the Ste. Genevieve. According to Ulrich the maximum thickness of his Ste. Genevieve in Kentucky is at least 245 feet, but the greatest measured section in Monroe County, Illinois, is about 75 feet, and it probably nowhere exceeds 100 feet. The thickness of the formation in its typical localities near Ste. Genevieve, Missouri, probably does not exceed that in Monroe County, Illinois. It is believed by the writer that some room for doubt exists as to the correctness of Ulrich's correlation of some of the beds in the extreme southern counties of Illinois which have been referred to the Ste. Geneveive limestone by him, and the description of the formation herein given applies only to its typical Mississippi Valley expression.

The Ste. Genevieve includes certain remarkably cross-bedded limestones which are commonly more or less arenaceous; some of the most conspicuously oolitic limestones in our entire Mississippian section; and also some beds which are wholly arenaceous. In the bluffs at Alton about 48 feet of limestone and more or less arenaceous strata are referable to this formation. The thickness increases to the south, for about 75 feet was actually observed in Monroe County, and a maximum thickness of 100 feet may be present. In Monroe County, where the formation is best known by the writer, the basal portion comprises the remarkably cross-bedded, more or less arenaceous limestones above mentioned. On Andy's Creek, in this county, a conspicuous 12-foot sandstone stratum may be seen lying about 20 feet above the lowermost observed beds of Ste. Gene-

[1] U. S. Geol. Survey, Prof. Paper, No. 36, p. 39 (1905).

vieve age in the section, and below about 20 feet of limestone. This sandstone is very fine-grained, yellowish, and very cross-bedded. It resembles, in some respects, the Rosiclare sandstone of Hardin County; and the section in which it occurs suggests the three-fold division of the Ste. Genevieve of that county, as described by Ulrich. In Monroe County, however, this bed does not appear to be a continuous formation, but only a local phase of the formation which has become wholly arenaceous.

The fauna of the Ste. Genevieve limestone is in part a recurrent fauna from the Salem limestone, but associated with these recurrent forms are certain others which are characteristic of the Ste. Genevieve. The best index fossil of the formation is probably *Pugnoides ottumwa*, originally described from the Pella beds of Iowa, which are to be correlated with these Ste. Genevieve limestones. Another good index species, but less common than the last, is *Girtyella indianensis*, which is also typical of the Pella beds of Iowa.

V. CHESTER GROUP

The name Chester Group was originally applied by Worthen to those strata of the Mississippian series typically exposed in Randolph County, from the base of the so-called "lower sandstone of the Chester group" to the summit of the Mississippian. The maximum thickness of this series of beds was estimated by Worthen to be at least 600 feet. A careful measurement of the Randolph County section by the writer gives a total thickness of about 550 feet, although a thickness of 743 feet is indicated in the Gilster well at Chester.

The local details of the Chester section vary from place to place, but the larger features are persistent over wide areas. The lowermost sandstone has long been recognized as a distinct formational unit and was called Cypress sandstone by Henry Engelmann[1] from certain extensive exposures on Cypress Creek in Johnson County. The series of beds superjacent to the Cypress was called the Kaskaskia limestone by Hall. More recent field investigations have made it clear that the series must be subdivided, and Ulrich, in his Kentucky work,[2] has defined two formations, the lower of which he calls Tribune limestone and the upper, Birdsville formation, which, together, constitute the Kaskaskia of Hall. However well this classification may apply to this series of beds in Kentucky, it is inapplicable in the typical Illinois section, and it has been found necessary, in the course of recent field work, to establish an entirely new series of formational units for the Chester group.

1 Trans. St. Louis Acad. Sci., vol. 2, pp. 189-190 (1863).
2 U. S. Geol. Survey, Prof. Paper, No. 36, pp. 55-66 (1905).

Brewerville formation.—The lower portion of the Chester group, as recognized by Worthen, and by Engelmann, is for the most part arenaceous, and the name Cypress sandstone, as used by Engelmann, and later by Ulrich, was originally applied to this lower sandstone member of the group.[1] Recent field studies have brought out the fact that two distinct formations are present in the Cypress, as it was originally defined, separated by a distinct unconformity and overlap. The lower of these two formations is the Brewerville, and the upper, the Renault formation. The Brewerville sandstone is well-exposed in the Mississippi River bluffs in Brewerville and Prairie du Rocher townships, between Modoc and Prairie du Rocher, in Randolph County, where the thickness of the formation is about 80 feet.

The formation consists of massive beds of fine-grained sandstone, which as a rule exhibit much cross-bedding. In its unweathered condition the sandstone is a light yellowish-brown, locally nearly white, but upon the exposed ledges it is more or less reddish-brown. It is the so-called "ferruginous sandstone" of some of the earlier writers upon the geology of the Mississippi Valley.

Wherever the Brewerville has been critically studied by the writer, it is separated from the subjacent formations by a distinct erosion unconformity, and rests locally upon the Ste. Genevieve and elsewhere directly upon the St. Louis limestone. In much of this area a conspicuous basal breccia is present at the contact of the Brewerville with the St. Louis. No fossils have ever been recorded from the formation and none have ever been found by the writer.

Renault formation.—The Renault formation has its typical development in the valley of Horse Creek and its tributaries in the eastern portion of Renault Township in Monroe County. It continues northward, where it is well developed east and northeast of Waterloo. To the south it is exposed in the Mississippi River bluffs below Modoc. The formation is exceedingly variable in its lithologic characters and includes sandstone, shale, and limestone members. Some of the sandstone members at or near the top of the Renault closely resemble the Brewerville, but they are commonly thinner bedded and are associated with arenaceous shales and with limestone lenses or more or less continuous strata of limestone. In many localities fossil tree trunks, lepidodendroids, are present in the sandstones of this formation, while no fossils of any sort have been observed in the Brewerville. Northeast of Waterloo, a conspicuous bed of variegated red and blue or gray shale is a notable member of the formation, and other less important beds of similar variegated shales occur elsewhere

[1] Engelmann also recognized certain beds of limestone and sandstone in Johnson County which he believed to be sub-Cypress in position, but no sub-Cypress Chester was ever recognized by Worthen in the typical Randolph County area.

in it. The thickness of the Renault varies from 40 feet or less to a maximum of 100 feet or more.

The Renault formation commonly overlaps the subjacent Brewerville to the west and rests directly upon the St. Louis or Ste. Genevieve limestone in unconformable contact, and this unconformity is also present between the Renault and the Brewerville itself. On Hickman Creek, northeast of Columbia, the Renault rests upon the Ste. Genevieve with a conspicuous basal conglomerate, and elsewhere in the same general region it rests upon the Brewerville with a basal conglomerate, mainly of limestone pebbles, but with some pebbles of crystalline rock. Eastward from the western margin of the Renault, away from the shore-line of the period, the limestone members of the formation become more and more conspicuous.

In some of the limestones and associated calcareous shales in the Renault, fossils are exceedingly abundant, the facies of the fauna being typically "Chester." The bryozoan genus *Archimedes*, however, is as a rule sparsely represented in the faunas and is in many places wholly absent, although in at least one locality it has been observed in abundance. The genus *Lyropora*, on the other hand, is in many localities exceedingly abundant. The crinoid fauna of these beds is the most varied and best preserved of any observed in the Chester group, *Talarocrinus* being one of the commonest genera of these organisms.

Yankeetown formation.—Overlying the Renault formation is a thin but most persistent siliceous formation of peculiar lithologic character, locally quartzitie. Although this bed is entirely unfossiliferous, so far as it has been observed, it has served as a key formation in the interpretation of the Chester succession to a greater extent than any other formational unit. Some of its most typical exposures may be seen in the region adjacent to the Yankeetown school, about 6 miles southwest of Red Bud, from which locality the name of the formation has been derived, but it occurs as well in the extreme north of the area of the outcrop of the "Chester", on Hickman Creek, northeast of Columbia, and near Millstadt. It is also well exposed in the Mississippi River bluff section one and one-half miles below Modoc, and at many intervening localities.

The thickness of the Yankeetown is probably nowhere over 20 feet, and commonly is less. Its color is light, commonly gray or yellowish, or in many localities nearly white. It is very irregularly, and more or less cross-bedded, having a decidedly knotty appearance, and locally is distinctly banded. It is commonly more or less arenaceous and in some localities certain beds are quartzitie. Where the formation is encountered in wells it appears to be a very hard, siliceous limestone, and in dug wells it usually puts an end to any further excavation. The Yankeetown is so hard and resistant that over considerable areas the superjacent beds were

removed by erosion in pre-Pennsylvanian time, and in such areas this formation constitutes the floor upon which the Pennsylvanian beds have been deposited.

There is reason to believe that the Yankeetown rests unconformably upon the subjacent Renault, since the immediately underlying strata are in some localities limestone, in others sandstone, and in still others shale.

Paint Creek formation—Above the Yankeetown formation is a series of strata approximating 60 feet in thickness, which are shales below, passing into limestones above. Near the base of this Paint Creek formation, either resting directly upon the Yankeetown or separated from it by a few feet of blue or gray shales with perhaps some thin calcareous beds, is a deep-red, clay member. Its summit is about 25 feet above the top of the Yankeetown chert in a tributary of Paint Creek about five and one-half miles northeast of Prairie du Rocher, from which locality the formation name has been taken. In fresh exposures this red bed exhibits little or no stratification; on being subjected to atmospheric agencies it first crumbles into small, angular fragments which eventually disintegrate into a fine, red mud. The appearance of the stratum is more that of a residual clay than anything else familiar to the writer. It is a constant member of the formation, being present throughout the entire extent of surface outcrop of this portion of the Chester group, and being recognized in deep-well records beyond this region.

No fossils have been found in the red-clay member of the Paint Creek formation, but in the succeeding calcareous shales and limestones fossils are common in many localities. Like the faunas of the Renault, the Paint Creek faunas are typically Chester in facies and contain many of the species which have usually been reported from the "Chester" or "Kaskaskia" limestone in the past. The genus *Archimedes* is more commonly present than in the Renault, although it is as a rule not abundant, as is commonly the case in some of the higher beds. *Lyropora* is also a common form in some localities, and among the brachiopods *Diaphragmus elegans* abounds in many places.

Ruma formation.—Succeeding the upper limestone member of the Paint Creek is a shale formation, in which a thin sandy member is usually present near or a little above the middle. These beds are most typically exposed in some of the tributaries of Horse Creek northeast of Ruma, and attain a thickness of 25 to 40 feet. The shales are in part variegated and in part blue or gray, this being, in fact, the highest conspicuous horizon of variegated shales in the Chester group. The shales have nowhere been observed to be fossiliferous, but in the sandstone member of the formation, lepidodendroid tree trunks, probably identical with those in the Renault, occur in many localities.

Okaw formation.—Succeeding the Ruma formation is an alternating series of limestones and shales attaining a thickness of about 200 feet. The shales of this Okaw formation are commonly blue or gray, rarely with a slight admixture of red and blue, which is such a conspicuous feature of some of the shale horizons lower in the section. The limestones vary greatly in texture, some being highly crystalline, some oolitic, and others rarely cherty. Their color is also variable from gray or blue to nearly white. At least four conspicuous limestone horizons are present in the Okaw, the highest of which is the quarry ledge at Menard in the Southern Illinois Penitentiary prison yard.

Both the shales and the limestones of the Okaw formation are commonly fossiliferous, and in many localities abundantly so. Within the formation are several more or less distinct faunal zones, although the details of the faunal distribution of the fossils has not yet been wholly worked out. At the base of the lowermost limestone member there is commonly present a zone, several feet in thickness, which is especially marked by the brachiopod genus *Martinia*, this being the only horizon from which members of this genus have been recognized. Associated with *Martinia*, in most localities, are great numbers of bases of the crinoid *Agassizocrinus*, along with other characteristic Chester forms. A few feet higher, still in the basal limestone member of the formation, wing-like plates from the ventral disk of *Pterotocrinus depressus* occur so abundantly in many localities as to almost entirely cover some surfaces of the limestone, in fact these plates of several species of *Pterotocrinus* constitute a very notable element in the faunas of the lower members of the Okaw formation. *Archimedes* is especially abundant in the faunas of the lower members of the formation, as well as a great variety of other bryozoans.

Some 60 feet above the base of the formation occurs a very constant oolitic limestone member, 10 or more feet in thickness, with a fauna in which many small pelecypods and gastropods are present.

The summit beds of the formation are usually calcareous shales with interbedded thin limestones, and locally a sandstone ledge 10 to 12 feet in thickness is present a few feet above the highest heavy ledge of limestone. These shaly, upper Okaw, beds are commonly abundantly fossiliferous, the large blastoid, *Pentremites sulcatus*, so far as it has been observed by the writer, being restricted to this horizon. Another species which has been found in most localities where fossils have been collected from these higher beds, and which has been seen at no other horizon, is *Archimedes laxus*.

The brachiopod species *Camarophoria explanata* is present in most of the Okaw faunas, and has been observed by the writer only rarely in any other Chester horizon. This formation has been the source of by far the

greater number of species which have been described by the various writers from the "Chester" of Illinois, and a full faunal list of the formation would include nearly all of the Chester or Kaskaskia species in our literature.

The various members of the Okaw formation are well exposed in the Mississippi River bluffs above and below the tributary Okaw or Kaskaskia valley, this valley being entirely excavated from the rocks of this formation at its point of juncture with the valley of the Mississippi, hence the name here adopted for the formation.

Menard formation.—The Menard is a conspicuous formation of limestone with interbedded shales, well exposed in the middle portion of the bluffs at Chester. One of its best exposures is immediately southeast of the hospital for criminal insane at Menard. In its typical expression, this formation is a thin and moderately thick-bedded limestone, the bedding planes being undulating and hummocky in character, with thin, shaly partings. In places these shaly partings become thicker, and shale beds of as much as five feet or more in thickness are present. The basal portion of the formation, where it is exposed, is seen to be shale, as much as 35 feet of fine, blue, clay shale being present in some localities between the top of the Okaw and the typical limestone beds of the Menard. The lithologic character of the limestone of the formation differentiates the Menard rather sharply from most of the limestone strata of the Okaw. The limestones of the lower formation are commonly more or less crystalline or granular, often crinoidal, sometimes oolitic, and usually free from chert. In the Menard the limestones are nearly always close-textured, fine-grained rocks, and there may be a small amount of chert; they are brittle, and often exhibit a conchoidal fracture. Because of the difference in texture, the weathered surfaces of the Menard are commonly smooth, those of the Okaw usually being more uneven. The color of freshly broken surfaces of the Menard is usually a bluish gray, while that of the Okaw limestone is commonly lighter, some beds being nearly white. Locally, there are crystalline strata in the Menard which closely resemble certain of the Okaw beds, but such strata are always of limited thickness and usually occur in the higher portion of the formation. The thickness of the Menard is about 80 feet. It is well exposed in the Mississippi River bluffs from Chester to Rockwood, and the valley of Mary's River, at its mouth, is excavated entirely through this formation into the higher beds of the Okaw.

The fauna of the Menard is very different from that of the Okaw. One of the most conspicuous species is a large pelecypod of the genus *Sulcatopinna*. This is associated with several other species of pelecypods, and with the large, typical forms of *Composita subquadrata* and *Spirifer increbescens*. *Pentremites* and *Archimedes* are not common in the formation

except locally in some of the uppermost beds, and but a single species of *Pentremites, P. cherokeeus* Hall, has been collected.

Palestine formation.—The formation succeeding the Menard is arenaceous throughout in most sections, consisting in part of heavy beds of sandstone suitable for building purposes, and in part of thinly bedded, ripple-marked sandstones or arenaceous shales. Locally, however, more argillaceous shales are well developed in the formation. The formation is present in the higher portion of the bluffs at Chester, and has been quarried at several points for building stone. The buildings of the penitentiary at Menard are constructed of this rock. The more sandy facies of the formation are exceedingly well exhibited along some of the tributaries of Tindall Creek, in Palestine Township of Randolph County. The thickness of the formation is about 75 feet, and it seems to lie with some degree of unconformity upon the subjacent Menard limestone. The only fossils which have been seen in the formation are fragments of Lepidodendron trunks.

Clore formation.—The highest formation in the Chester Group in Randolph County, is a limestone immediately overlying the Palestine sandstone. The greatest thickness actually measured is 30 feet, but it certainly exceeds this thickness in many localities. The transition beds from the underlying sandstone to the Clore limestone, consist of arenaceous and calcareous shales, with some beds of limestone, occupying, in places, an interval of as much as 25 feet below the more continuous limestone strata. The lithologic characters of the limestone beds are variable, some being thin bedded and almost shaly, others being similar to the Menard in texture and hardness, but usually darker in color, while others are more granular or crystalline. Some shale beds are included in the formation.

The Clore limestone caps the summits of the hills upon which the city of Chester is built, and it outcrops in the heads of several of the ravines adjacent to the town. The formation also caps some of the higher hills east and northeast of Chester until it passes beneath the overlying Pennsylvanian. Typical exposures of it occur in the heads of the ravines along the southwest side of the high ridge, extending from Clore school to the Randolph County farm. The most extensive exposures which have come under observation are in Bremen Township of Randolph County, about two miles northeast of the village of Bremen, where a small anticlinal flexure causes its surface outcrops to spread out on either side of Little Mary's River.

The fossils of the Clore limestone are locally more conspicuous than those of the Menard. Some of the shaly beds are filled with fossils and are suggestive of certain phases of the Okaw formation, but the association of species is different. In those beds resembling the Menard in texture, some of the Menard species are commonly present.

Descriptions of Genera and Species

Class BRACHIOPODA

Order ATREMATA

Family LINGULIDÆ

Genus *LINGULA* Bruguiere

Description.—Shell thin, linguiform or tongue-shaped, subequivalvate, elongate-ovate or subquadrate in outline. Brachial valve slightly shorter than the pedicle and with a slightly thickened hinge-line. The pedicle opening common to the two valves. Surface of the valves usually shining, smooth or marked by concentric or radiating striæ. Internally, the muscular impressions are numerous but usually indistinct.

Remarks.—The genotype of *Lingula* is the recent species *L. anatina,* but from the state of our knowledge of the characters of the ancient species which have been referred to the genus, there seems to be reason for separating only a few of them generically from the living forms. It is true that the internal characters, especially the arrangement of the muscular scars, are insufficiently known or wholly unknown in many of the species which have been described from Paleozoic faunas, and it is possible that with future increased knowledge of these characters other generic differentiations may be drawn. Ordinarily it is difficult or impossible to differentiate between the two valves of a fossil species of *Lingula.*

Lingula membranacea Winchell

Plate I, Fig. 5

1863. *Lingula membranacea* Winchell, Proc. Acad. Nat. Sci. Phil., p. 3.
1900. *Lingula membranacea* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 65, pl. 1, fig. 20.

Description.—Shell ovate-subquadrangular in outline, the greatest width towards the front, the valves very flat. Postero-lateral margins nearly straight as they approach the beak, where they meet in a very broadly obtuse angle, rounding into the lateral margins distally; lateral margins nearly straight or very gently convex, diverging slightly anteriorly; the antero-lateral margins rounding into the truncated anterior margin. The beak depressed and inconspicuous, not quite reaching the posterior margin. Surface marked only by concentric lines of growth varying

somewhat in strength and usually situated about one-half millimeter apart. The dimensions of the type specimen are: length, 12 mm.; greatest width, 8 mm.; width at postero-lateral extremities, 6 mm.

Remarks.—The holotype only of this species has been observed, an illustration of which is given on the accompanying plate. The specimen is a single valve, whether pedicle or brachial cannot be determined, lying upon a fragment of fine-grained, yellow sandstone. It is imperfect, being somewhat broken upon the margins, but seems to be sufficiently distinct from any of the other species recognized, and may be distinguished by its ovate-subquadrangular outline. The specimens from the Waverly formations of Ohio and Pennsylvania which have been identified with this species by Winchell, Meek, and Herrick, are all specifically different from this Iowa shell.

Horizon.—Chonopectus sandstone of the Kinderhook.

Lingula louisianensis n. sp.

Pate I, Fig. 3

Description.—Shell small, much compressed, ovate-subquadrangular in outline, the lateral margins gently convex in the central portion, postero-laterally the curvature increases and passes into the somewhat narrowly rounded posterior margin, antero-laterally the curvature increases more abruptly than posteriorly, passing into the broadly rounded or subtruncate anterior margin. The dimensions of a nearly complete valve are: length 9.7 mm., width 5.6 mm.

Surface of the brachial (?) valve, in the internal cast, compressed along the postero-lateral margins, the apex of the convex portion of the valve lying a little within the apex of the posterior margin, a slight median ridge, indicated by a depression in the surface of the internal impression, passes anteriorly from near the apex of the valve for nearly half its length.

Surface of the valve nearly smooth, marked by fine, but somewhat irregular lines of growth, and by the faintest suggestion of radiating striæ.

Remarks.—The specimen from which the above description has been made is a nearly complete internal cast of what seems to be a brachial valve, with only fragments of the shell itself preserved. The external surface is not well preserved anywhere, all that can be seen being restricted to a few fragments of the shell still retained on the specimen. In size and general form the species resembles *L. gorbyi* from the Chouteau limestone, from which species it may be distinguished by reason of its subtruncate anterior margin.

Horizon.—Louisiana limestone of the Kinderhook.

LINGULA GORBYI Miller

Plate I, Figs. 1, 2

1892. *Lingula gorbyi* Miller, Adv. Sheets 18th Rep. Geol. Surv. Ind., p 55, pl. 9, figs. 3, 4.
1894. *Lingula gorbyi* Miller, 18th Rep. Geol. Surv. Ind., p. 309, pl. 9, figs. 3-4.

Description.—Shell small, subelliptical in outline, the width more than one-half the length. The dimensions of a nearly complete valve are: length 11 mm., width 7.2 mm.

Valves gently convex, the anterior margin subsemicircular, the lateral margins gently convex, the postero-lateral margins nearly straight or gently convex and meeting at the beak in a rounded, obtuse angle. Surface marked by very fine, exceedingly regular, concentric costæ, from 12 to 15 of which occupy the space of 1 mm., and usually by rather obscure concentric undulations.

Remarks.—This species may be recognized by its exceedingly regular concentric costæ.

Horizon.—Chouteau limestone of the Kinderhook.

LINGULA HALLI White

Plate I, Fig. 4

1862. *Lingula Halli* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 30.

Description.—Shell very small, longitudinally subelliptical in outline, the length about twice the width, the greatest width a little in front of the middle; the postero-lateral margins meeting at the beak in an acute angle, the lateral margins gently convex, the anterior margin narrowly rounded. The dimensions of the holotype are: length 6.1 mm., greatest width 2.8 mm., convexity of pedicle valve .8 mm.

Pedicle valve rather strongly convex in proportion to the width, the greatest convexity posterior to the middle; the beak, in the internal cast, rather abruptly constricted and produced posteriorly a little beyond the general margin of the valve. Surface marked by fine, concentric lines of growth, somewhat variable in strength.

Brachial valve imperfectly preserved, its convexity evidently about equaling that of the pedicle valve.

Remarks.—The holotype of this species is an internal cast of what is probably the pedicle valve, preserved upon a fragment of white chert. The reverse of the same chert fragment preserves small portions of the shell substance of this valve and the incomplete brachial valve, somewhat displaced, exhibiting the internal surface of its posterior portion. The species differs notably from any of the other recognized Lingulas in the faunas under consideration, in its narrowly subelliptical shell, approach-

ing in its outline *L. spatulata* of the Genesee shale of the New York Devonian. The species, however, is larger than the illustrated examples of *L. spatulata,* and is more narrowly rounded at the anterior margin.

Horizon.—Burlington limestone.

Lingula varsoviensis Worthen

Plate I, Fig. 6

1884. *Lingula varsoviensis* Worthen, Bull. No. 2, Ill. State Mus. Nat. Hist., p. 24.
1890. *Lingula varsoviensis* Worthen, Geol. Surv. Ill., vol. 8, p. 104, pl. 11, fig. 8.

Description.—Shell rather large for the genus, subovate in outline, the width about two-thirds the length, the greatest width anterior to the middle. The dimensions of the holotype are: length 21.8 mm., greatest width 14 mm.

The valves moderately convex, the greatest depth posterior to the middle; the anterior margin subsemicircular, the lateral margins gently convex, the posterior margin shorter than the anterior, the posterolateral margins meeting at the beak in a broadly obtuse angle and rounding somewhat abruptly into the lateral margins distally, the beak apparently not prominent. The surface marked by numerous, regular, crowded, concentric lines of growth which are somewhat variable in strength, becoming more crowded towards the margins; the median one-fourth of the valve is marked by faint, radiating costæ which are only noticeable anteriorly from the middle of the valve.

Remarks.—This species is one of the larger members of the genus in the faunas under consideration, being equalled in this respect only by *L. indianensis.* These two species are, indeed, closely allied and should perhaps be considered as synonymous, but owing to the limited number of specimens examined, the holotypes of the two species, it is not possible to certainly determine their identity. The type of *L. indianensis* is relatively a little broader, a character which may be due to the somewhat crushed condition of the specimen, the concentric markings of the two specimens are entirely similar in strength and expression, but the *L. indianensis* does not possess the faint radiating costæ in the median portion of the valve which are present upon *L. varsoviensis.* For the present the two species will be considered as distinct, their separation being based upon the presence of the faint, radiating costæ in *L. varsoviensis* and their absence in *L. indianensis.* More extensive collections may show that this character is not of sufficient value to be used as a means of separating the two forms specifically, in which case Worthen's name *L. varsoviensis* will be applicable to all of the specimens.

Horizon.—Warsaw beds.

Lingula indianensis Miller and Gurley

Plate I, Fig. 7

1894. *Lingula indianensis* Miller and Gurley, Bull. No. 3, Ill. State Mus. Nat. Hist., p. 69, pl. 7, fig. 1.

Description.—Shell rather large for the genus, subovate in outline, the length about one-half greater than the width, the greatest width anterior to the middle. The dimensions of the type specimen are: length 21.8 mm., width 14.9 mm.

Valves gently convex, the anterior margin subsemicircular, the lateral margins gently convex, the posterior extremity much narower than the anterior, the postero-lateral margins meeting at the beak in a very broadly obtuse angle and rounding rather abuptly into the lateral margins; the beak not prominent. Surface marked by fine concentric lines of growth towards the beak, which become coarser, more irregular and more or less undulatory towards the margins.

Remarks.—This species may be recognized by its subovate outline, its rather large size, and its more or less irregular concentric markings. It is most closely allied to *L. varsoviensis*, from which it can be distinguished only by the absence of fine radiating costæ from the median portion of the valve.

Horizon.—Crawfordsville shale.

Genus *GLOSSINA* Phillips

Description.—Shell thin, broadly ovate-subtrigonal in outline, acuminate posteriorly and rounded anteriorly. Surface of the shell usually shining as in *Lingula*, and marked by concentric lines of growth. The internal markings of the valves obscure and imperfectly known.

Remarks.—This genus has been established to include a few linguloid species which differ from *Lingula* proper in the subtrigonal outline of the shell. The internal characters of the shell are not sufficiently well known to make it possible to determine whether or not the arrangement of the muscular scars corresponds with that of *Lingula*.

Glossina sedaliensis (Miller)

Plate I, Fig. 11

1892. *Lingula sedaliensis* Miller, Adv. Sheets 18th Rep. Geol. Surv. Ind., p. 54, pl. 9, fig. 2.

1894. *Lingula sedaliensis* Miller, 18th Rep. Geol. Surv. Ind., p. 308, pl. 9, fig. 2.

Description.—Shell triangularly subovate in outline, longer than wide, the greatest width towards the anterior margin. The approximate dimensions of a large but very incomplete example are: length ±17 mm., width ±13 mm.

Valves depressed convex, the anterior margin broadly rounded, approaching subcircular, passing gradually into the elongate, nearly straight postero-lateral margins, meeting in an acute angle at the beak, which is sometimes narrowly rounded. Surface marked by slender, raised, regular, concentric costæ, with broad, flattened spaces between, about four or five occupying the space of one millimeter in the median portion of mature shells towards the front, becoming much crowded towards the postero-lateral margins.

Remarks.—This species may be easily recognized by its subtriangular form and by the style of its surface markings.

Horizon.—Chouteau limestone.

Glossina lineolata (Rowley)

Plate I, Fig. 12

1908. *Lingula lineolata* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., pp. 87 and 100, pl. 19, figs. 35-36; pl. 20, figs. 19-21.

Description.—Shell small, compressed, broadly triangularly subovate in outline, the greatest width anterior to the middle. Anterior margin broadly rounded and passing regularly into the lateral margins, the postero-lateral margins long, gently convex, meeting at the beak, the angle being 90 degrees or less. The dimensions of one of the co-types are: length 8 mm., width 7.5 mm.

Ventral (?) valve compressed, the greatest depth posterior to the middle, the convex curvature of the surface more abrupt to the postero-lateral margins. Surface marked by strong, regular, sublamellose, concentric markings.

Remarks.—This species was described by Rowley from two specimens which may possibly belong to two different species. The above description is based upon the smaller of the two cotypes. In its great relative width this specimen resembles the subtrigonal linguloid shells which have been placed in the genus *Glossina*, and by reason of that character alone the species is here included in that genus. The species differs from *G. sedaliensis* of the Chouteau limestone in its smaller size, its less acute beak, and in its more crowded and more sublamellose concentric markings.

Horizon.—Louisiana limestone.

Order NEOTREMATA

Family DISCINIDÆ

Genus *ORBICULOIDEA* d'Orbigny

Description.—Shell subcircular or subelliptical in outline, inequivalvate. Pedicle valve nearly flat or depressed-convex, with the apex excentric and inclined slightly towards the posterior margin; a pedicle groove originates at the apex of the valve, passes posteriorly for a short distance, beyond which point it is continued as a pedicle tube which pierces the substance of the valve very obliquely, opening to the interior near the posterior margin. Brachial valve depressed conical, with the apex excentric and inclined posteriorly. Surface of the valves smooth, or more commonly marked by concentric lines, and more rarely by fine radiating costæ.

Remarks.—The species of this genus are most commonly represented by the subconical brachial valves, and it is from the form, proportions, and surface characters of these valves that most of the species have been differentiated. Specimens of the pedicle valves are less commonly preserved, and when seen the course of the oblique pedicle opening can rarely be traced.

Orbiculoidea capax (White)

Plate I, Fig. 13

1862. *Discina capax* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 30.
1900. *Orbiculoidea capax* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 65, pl. 1, fig. 19.

Description.—Shell below medium size, subcircular in outline, length and breadth probably about equal. The dimensions of the holotype are: maximum diameter 22 mm., convexity of brachial valve approximately 5 mm.

Pedicle valve not known.

Brachial valve depressed conical, the apex excentric posteriorly and inclined towards the posterior margin, apparently situated about one-fourth or one-fifth the length of the valve from the posterior margin, the greatest convexity of the valve in front of the apex; the surface gently convex from the apex to the anterior margin, sloping more abruptly to the lateral margins, and a little concave to the posterior margin. The surface marked by fine, regular, concentric lines of growth, and by more or less obscure radiating lines.

Remarks.—The holotype of this species, which is the only example seen, is a much crushed and imperfect brachial valve, the entire outline of which cannot be determined. The central portion of the valve, however,

is well preserved, and in the preparation of the above description it has been assumed that the form and contour of the shell, as indicated by the growth lines of this central region, represents the outline of the entire shell. The species has been identified by Winchell from the Marshall and Waverly formations of Michigan and Ohio, but the specimens so identified are probably different from this Chonopectus sandstone shell.

Horizon.—Chonopectus sandstone of the Kinderhook.

Orbiculoidea sampsoni (Miller)

Plate I, Figs. 21, 22

1891. *Discina sampsoni* Miller, Adv. Sheets 17th Rep. Geol. Surv. Ind., p. 80, pl. 13, figs 10, 12.
1892. *Discina sampsoni* Miller, 17th Rep. Geol. Surv. Ind., p. 690, pl. 13, figs. 10, 12.

Description.—Shell small, suboval in outline, the length usually greater than the width. The dimensions of one of the type specimens, a brachial valve, are: length 12.5 mm., width 12 mm., convexity 2.8 mm.

Pedicle valve nearly flat, marked by regular, nearly equidistant, concentric lines, about four of which occupy the space of 1 mm.; the pedicle opening excentric.

Brachial valve conical, with the apex excentric posteriorly and inclined posteriorly, its distance from the posterior margin being variable, the greatest depth of the valve usually slightly in front of the apex, the surface sloping with a gently convex curvature from the apex to the anterior and antero-lateral margins, becoming slightly concave to the postero-lateral and posterior margins, in some specimens with the beak situated more than usually posterior, the posterior slope is nearly vertical. Surface marked by fine, regular, concentric lines of growth which are somewhat variable in strength, and by exceedingly fine radiating lines which can be detected upon well-preserved specimens only, with a good lens. Internally, a slightly elevated and very narrow ridge extends anteriorly from the apex for about one-third the distance to the anterior margin, and in front of its anterior extremity is a transverse series of four, small, slightly elongated papillæ.

Remarks.—The muscular impressions on the interior of the brachial valve, represented by the slight median ridge and four papillæ mentioned above, have been observed in only one example, one of the co-types, where they appear as depressions in the surface of the internal cast where the test has been removed.

Horizon.—Chouteau limestone of the Kinderhook.

Orbiculoidea keokuk (Gurley)

Plate I, Figs. 14-17

1884. *Discina Keokuk* Gurley, New Carboniferous Foss., Bull. No. 2, p. 6.

Description.—Shell rather large for the genus, subcircular in outline. The dimensions of a pedicle valve, one of the cotypes, are: length 16.5 mm., width 18 mm. The width of a second cotype is 21 mm.

Pedicle valve nearly flat, the pedicle opening excentric, its external surface marked by regular, sublamellose, concentric lines of growth.

Brachial valve depressed conical, the apex situated at about one-fourth the length of the shell from the anterior margin, the surface apparently gently convex from the apex to the anterior and lateral margins and slightly concave to the posterior margin. The surface marked by fine, crowded, rounded, raised, concentric lines of growth which are apparently somewhat irregular in their development and distribution. Internally a slight median ridge extends anteriorly from the apex for about one-third the distance to the anterior margin of the valve.

Remarks.—The above description is based upon the two cotypes of the species from Crawfordsville, Indiana. The brachial valve is incomplete posteriorly so that the exact position of its apex, relative to the posterior margin, cannot be determined. The length of the valve is also uncertain, and, since it is more or less crushed, the depth, as well as the contour of the sloping surface from the apex to margins, cannot be accurately determined. The shell substance is largely exfoliated, but enough is preserved to show the character of the surface markings. The species is characterized by its nearly circular outline and the nature of its surface markings.

Horizon.—Keokuk (Crawfordsville shale).

Orbiculoidea varsoviensis (Worthen)

Plate I, Figs. 23, 24

1884. *Discina varsoviensis* Worthen, Bull. No. 2, Ill. State Mus. Nat. Hist., p. 23.

1890. *Discina varsoviensis* Worthen, Geol. Surv. Ill., vol. 8, p. 102, pl. 11, fig. 7.

Description.—Shell rather large for the genus, subelliptical in outline. The dimensions of the holotype are: greater diameter 19.5 mm., lesser diameter 16.1 mm.

Pedicle valve nearly flat; the pedicle opening situated excentrically in the line of the longer axis of the valve, and extending from the center of the valve half way to its posterior margin, its lateral margins elevated upon the internal surface of the valve to form an elongate, subovate prominence which is probably a depression or excavation externally. The external surface marked by sublamellose, concentric lines of growth, from two to three of which occupy the space of 1 mm.

Brachial valve imperfectly preserved in the only example observed, the degree of convexity not known, its surface marked by more or less regular, sublamellose, concentric markings similar in form and size to those of the opposite valve, and by very faint radiating costæ upon the flattened spaces between the concentric markings.

Remarks.—Only two specimens of this species have been examined by the writer, these being the original types. The best preserved example is the inner surface of a pedicle valve which has been illustrated by Worthen. The second specimen is a fragment of limestone upon which two valves are crushed, partially overlapping, one apparently being a pedicle valve and the other a brachial. In its concentric surface markings the species resembles *O. keokuk,* but it differs from that species in its subelliptical rather than subcircular outline.

Horizon.—Keokuk limestone.

Orbiculoidea batesvillensis Weller

Plate I, Figs. 19, 20

1897. *Orbiculoidea batesvillensis* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 255, pl. 18, figs. 4-5.
1909. *Lingulidiscina batesvillensis* Girty, Bull. U. S. Geol. Survey No. 377, p. 22, pl. 1, figs. 12-12a.

Description.—Shell subcircular or subovate in outline. The dimensions of two individuals, the cotypes, are: length 17 mm. and 16 mm., width 15.5 mm. and 17 mm., convexity 3.8 mm. and 3.5 mm.

Pedicle valve not known.

Brachial valve depressed convex, subconical, the apex small and inconspicuous, inclined posteriorly, and situated excentrically from one-fifth to one-seventh the total length of the valve from the anterior margin, the greatest depth of the valve posterior to the apex, in some specimens notably so; the surface gently convex throughout from the central portion to the margins, except for a short space back of the apex. The surface markings are concentric in arrangement so far as can be determined from the internal casts.

Remarks.—This species was established upon two internal casts of the brachial valve especially characterized by their small apices which are distinctly lower than the greatest convexity of the valve anteriorly. It is possible that the apex of the valve would be somewhat more prominent in specimens preserving the shell itself, but it must always have been inconspicuous as compared with other species of the genus.

Horizon.—Batesville sandstone, Batesville, Arkansas.

Family CRANIIDÆ

Genus *CRANIA* Retzius

Description.—Shell subcircular in outline, usually more or less unsymmetrical in its growth, inequivalvate. Pedicle valve without perforation for the passage of a fleshy pedicle, attached by its apex or by its entire external surface to some external object. Brachial valve depressed-subconical, with a subcentral, erect or posteriorly directed apex. The interior of each valve is marked by two pairs of large adductor muscular scars, the posterior pair being close to the margin and widely separated, the anterior pair being much closer together and subcentrally located. The external surface of the brachial valve marked by more or less irregular concentric lines of growth, by regular radiating costæ, or by fine setæ or pustules.

Remarks.—The more regular examples of the brachial valves of *Crania* may be distinguished from members of the genus *Orbiculoidea* by the more nearly central position of the apex and its more erect position. These valves of the two genera also may be commonly differentiated by reason of the less regular manner of growth in the genus *Crania*.

It seems hardly justifiable to include in one generic group all the species which are here referred to the genus *Crania*. Such species as *Crania rowleyi* having the shell marked by conspicuous radiating costæ can hardly be congeneric with such species as *Crania reposita*, for instance, which have a fundamentally different type of surface markings, and perhaps the species marked by the fine setæ or pustules should be made to constitute a third genus. These three types of surface markings persist throughout the Paleozoic faunas where these shells are present, and so far as the writer is aware, there is never any question as to the differentiation of the groups. No generic names are proposed for these distinct groups of species at this time, however, it being deemed best to defer such action until a larger number of species from all the different geological time periods are more critically studied.

Crania missouriensis Weller

Plate I, Fig. 30

1909. *Crania missouriensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 292, pl. 12, fig. 1.

Description.—Shell rather large for this genus, subcircular in outline. The dimensions of the type specimen are: length 17 mm., width 17 mm.

Pedicle valve attached to some external object, in the case of the type to the interior of the shell of a *Productus*, its characters not observed.

Brachial valve depressed, with the apex rather obscure and situated excentrically about one-third the length of the shell from the anterior mar-

gin; in the type specimen the greatest depth of the valve lies posterior to the apex near the center and the central portion is depressed convex; towards the margin the surface becomes concave, but this contour is doubtless due to the strongly concave surface upon which this individual has grown, and in other situations it would doubtless be depressed convex throughout. Surface marked by rather fine, but more or less irregular and uneven concentric markings.

Remarks.—It is not possible to compare this species with all the named forms from these Mississippian faunas for the reason that several have been described very briefly without accompanying figures. It seems to be sufficiently distinct from all of them, however.

Horizon.—Fern Glen formation.

Crania dodgei Rowley

Plate I, Fig. 32

1908. *Crania dodgei* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 73, pl. 17, figs. 5-6.

Description.—Shell below medium size, subcircular in outline, the holotype attached to a shell of *Spirifer marionensis.* The dimensions of the holotype are: greatest diameter 17 mm., convexity of brachial valve 6 mm.

Pedicle valve entirely covered by the brachial in the two specimens examined, apparently attached by its entire external surface.

Brachial valve depressed conical, the apex subcentral or somewhat eccentric in position, erect or slightly inclined, the surface sloping in all directions from the apex with a gently convex curvature. The surface marked by rather strong, crowded, irregular, concentric lines of growth, and by very fine, obscure, and interrupted radiating striæ.

Remarks.—Only a few examples of this species have been observed but their irregular, crowded, concentric lines of growth with obscure radiating striæ will serve to distinguish them from other species.

Horizon.—Louisiana limestone.

Crania reposita White

Plate I, Figs. 25, 26

1862. *Crania reposita* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 30.

Description.—Shell small, subcircular, subelliptical, subovate or subquadrate in outline, the types attached to a shell of *Spirifer grimesi.* The dimensions of the largest of the type specimens are: greater diameter 13.5 mm., lesser diameter 11.1 mm.

Pedicle valve firmly cemented by its entire external surface, its periphery thickened in a ring-like marginal border; the anterior adductor muscular scars contiguous, situated a little eccentrically and distinctly

elevated above the inner surface of the valve, the posterior pair situated just within the raised marginal border and rather widely separated, much less elevated than the anterior pair.

Brachial valve apparently wanting from all the specimens seen.

Remarks.—This species is known only from the types which consist of five individuals attached to one shell of *Spirifer grimesi.* The species may be recognized by its size, the raised marginal border of the pedicle valve and the conspicuously raised anterior muscular scars.

Horizon.—Burlington limestone.

Crania chesterensis Miller and Gurley

Plate I, Figs. 27-29

1897. *Crania chesterensis* Miller and Gurley, Bull. No. 12, Ill. State Mus. Nat. Hist., p. 47, pl. 3, figs. 24-26.

Description.—Shell small, gregarious in habit, subcircular in outline. The dimensions of one of the type specimens are: greater diameter 8 mm., lesser diameter 7 mm.

Pedicle valve, which is firmly cemented to external objects, not observed.

Brachial valve depressed, thin except at the apex and about the outer margin, the apex subcentral; in the condition of preservation of all the specimens examined, the thinner portion of the valve between the apex and the periphery, appears to be collapsed or depressed, leaving a distinctly elevated marginal rim and a node-like subcentral elevation at the apex. Surface marked only by sublamellose, concentric lines of growth which are somewhat crowded near the periphery but are much less conspicuous upon the collapsed portion of the valve and towards the apex.

Remarks.—This little species grows most commonly upon the thickened borders of species of the bryozoan *Lyropora,* but it also occurs sometimes upon the fenestrated portion of the same bryozoan, and a single specimen has been observed attached to the shell of a *Spirifer.* The species can be easily recognized, as it is commonly preserved, by the raised peripheral ring, and the raised central node. Whether the raised peripheral ring is due to the thickening of the brachial valve at the margin, as has been suggested in the above description, or whether it is due to the presence of a raised or thickened margin of the under or pedicle valve, cannot be certainly determined from the specimens, but perhaps the latter supposition is most probable, in which case the entire brachial valve is thin except at its apex.

Horizon.—Chester group.

Crania rowleyi Gurley

Plate I, Figs. 37-39

1883. *Crania Rowleyi* Gurley, New Carb. Foss., Bull. No. 1, p. 3.
1892. *Crania Rowleyi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 4H, fig. 13.
1908. *Crania rowleyi* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 73, pl. 17, figs. 3-4.

Description.—Shell small, subcircular or subovate in outline, attached to shells of brachiopods or molluses. The dimensions of a normal specimen are: maximum diameter 10 mm., convexity of brachial valve 2.5 mm.

Pedicle valve not observed, firmly attached to a foreign object.

Brachial valve conical, the apex of the cone a little eccentric, the sides of the valve from the apex to the margin nearly straight or very gently convex. Surface marked by fine, abruptly elevated, radiating costæ, which increase regularly by intercalation, and about three of which occupy the space of 1 mm. Crossing the costæ upon shells of normal size, there are usually two or three more or less conspicuous, concentric lines of growth occurring at nearly regular intervals.

Remarks.—This little shell belongs to that division of the genus *Crania* characterized by distinct radiating costæ. It is confined to the Louisiana limestone fauna, so far as known, and need be compared only with *C. blairi* of the Chouteau limestone which has sometimes been considered as a synonym. *C. rowleyi*, however, is a smaller shell, with more eccentric apex, and with somewhat coarser costæ.

Horizon.—Louisiana limestone.

Crania blairi Miller

Plate I, Figs. 34-36

1892. *Crania blairi* Miller, Adv. Sheets 18th Rep. Geol. Surv. Ind., p. 56, pl. 9, figs. 5-6.
1894. *Crania blairi* Miller, 18th Rep. Geol. Surv. Ind., p. 310, pl. 9, figs. 5-6.

Description.—Shell small, subcircular or subovate in outline. The dimensions of a normal example are: maximum diameter 14 mm., convexity of brachial valve 5 mm.

Pedicle valve attached to foreign objects not observed.

Brachial valve conical with the apex of the cone subcentral, the sides of the valve from the apex to the margins gently convex. Surface marked by fine, sharp, radiating costæ which increase by intercalation and which are often somewhat flexuous, especially on the outer half of the valve, three or four usually occupying the space of 1 mm. Crossing the radiating costæ, one or more inconspicuous, concentric lines of growth are sometimes present, but they are never a strongly marked feature.

Remarks.—This species has sometimes been considered as a synonym of *C. rowleyi*, but a careful comparison of numerous examples of both species has led to the conclusion that they are certainly distinct. *C. blairi* attains a larger size than *C. rowleyi*, which alone, of course, would not constitute a good specific character; but in addition the apex of the brachial valve is more nearly central and its radiating costæ are finer, more sharply angular, closer together, and are not infrequently somewhat flexuose distally, and the concentric lines of growth are less conspicuous.

Horizon.—Chouteau limestone.

Crania spiculata Rowley

Plate I, Fig. 31

1908. *Crania spiculata* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 74, pl. 17, figs. 7-10.

Description.—Shell below medium size, subcircular in outline, the holotype attached to a shell of *Syringothyris hannibalensis*. The dimensions of the holotype are: greatest diameter 13.7 mm., convexity of brachial valve 5 mm.

Pedicle valve apparently cemented by its entire external surface, entirely covered in the holotype and in other examples observed.

Brachial valve depressed conical, the apex central and erect, the surface sloping in all directions from the apex in straight or gently convex lines. The surface marked by more or less obscure concentric lines of growth and covered by fine, closely crowded papillæ which are slightly elongate radially with their distal extremities more elevated than their proximal, apparently being the bases of fine, appressed spines which have covered the entire surface of the valve in life, but whose length cannot be determined from the fossil specimens studied.

Remarks.—This species may be easily recognized by its finely papillose surface markings. It differs from the similarly marked Burlington limestone species, *C. lævis*, in its apparently more nearly circular outline, its more nearly central apex, and in the coarser surface papillæ.

Horizon.—Louisiana limestone.

Crania lævis Keyes

Plate I, Fig. 33

1894. *Crania lævis* Keyes, Mo. Geol. Surv., vol. 5, p. 40.

Description.—Shell below medium size, transversely subelliptical in outline, with the posterior margin truncated. The dimensions of one of the type specimens are: greater diameter or width 17 mm., lesser diameter or length 13 mm., length of posterior truncated margin 10.8 mm., convexity of brachial valve 4 mm.

Pedicle valve not known.

Brachial valve depressed conical, the apex situated a little eccentrically towards the posterior margin and inclined posteriorly, the surface sloping with a gently convex curvature from the apex to the lateral and anterior margins, becoming a little concave to the posterior margin. Internally the adductor muscular scars are well defined, the anterior pair rather close together, situated one at each side of the apex of the valve, the posterior pair somewhat larger than the anterior, marginal in position, much farther apart than the posterior, the distance from center to center being considerably greater than their distance from the anterior scars. External surface of the valve marked by rather obscure concentric lines of growth, and entirely covered by minute, crowded papillæ which may indicate the presence of minute, appressed spines upon the living shell.

Remarks.—The name *lævis,* given to this species by Keyes, suggests a smooth shell, but the specimen here described and illustrated, which was one of the original types, is clearly papillose when examined under a lens, although it does appear almost smooth to the unaided eye. The specimen is a silicified one, and it is possible that the author of the species mistook these minute papillæ for irregularities of the surface due to the silicification of the shell. The species was originally recorded from the Choutcau and Burlington limestones at Louisiana, Mo., so that the co-types must have been at least two in number, although neither of them were illustrated. The specimen here figured is the Burlington limestone specimen used by Keyes, now preserved in the collection of Prof. R. R. Rowley at Louisiana. No other example has been observed. The species differs from *C. spiculata* of the Louisiana limestone in its less circular outline, the more eccentric apex, and the finer surface papillæ.

Horizon.—Burlington limestone.

Order PROTREMATA

Family STROPHOMENIDÆ

Genus *LEPTÆNA* Dalman

Description.—Shell plano-convex in youth, becoming normally concavo-convex at maturity, transversely subtrapezoidal or semielliptical in outline, hinge-line straight, its length usually the greatest width of the shell, the cardinal extremities often subauriculate. Pedicle valve with a narrow cardinal area, the delthyrium closed by a convex deltidium, perforated at the apex of the beak by a foramen which is commonly filled at maturity. Brachial valve with a cardinal area narrower than that of the pedicle valve, the cardinal process large and bifid, surrounded posteriorly by a well-developed chilidium. The surface of both valves marked posteriorly by conspicuous concentric corrugations and where these cease

the valves are more or less abruptly and often rectangularly deflected to form a conspicuous anterior slope. The entire external surface is also covered by fine, regular, radiating costæ which increase by intercalation and bifurcation, and by still finer concentric markings.

Remarks.—Wherever members of this genus have been recorded they have usually been referred to the single species *L. rhomboidalis* Wilck., and while it is true that representatives of this so-called species throughout its entire geologic range, resemble each other more or less closely, it is also true that the individuals associated together in any one fauna do possess characteristics by means of which they may be distinguished from any other group of individuals from another fauna. There may be a difference of opinion as to whether these groups should be given specific or varietal rank, but in the opinion of the writer they should be considered as distinct species, there being no advantage in using varietal names for groups of individuals which can be clearly differentiated, and for the purposes of the stratigrapher it is necessary that the several forms should have some designation by which they may be referred to. Among the Mississippian faunas here considered, there are at least two forms which are sufficiently distinct to be easily differentiated, neither one of which, it is believed, can be referred to the typical *L. rhomboidalis*. In Great Britain the Mississippian form of *Leptæna* is commonly called *L. analoga*, and one of the forms in our faunas is here referred to that species, although it is not possible to determine from Phillip's original description and figure just what the essential characters of the species are.

LEPTÆNA ANALOGA (Phillips)

Plate II, Figs. 1-10

1836. *Producta analoga* Phillips, Geol. Yorkshire, vol. 2, p. 215, pl. 7, fig. 10.
1859. *Strophomena rhomboidalis* var. *analoga* Davidson, Brit. Foss. Brach., vol. 2, p. 119, pl. 28, figs. 1-2.
1874. *Strophomena rhomboidalis* White, Prelim. Rep. Inv. Foss., p. 17.
1877. *Strophomena rhomboidalis* White, U. S. Geog. Surveys, W. 100th Mer., vol. 4, p. 85, pl. 5, fig. 5.
1877. *Strophomena rhomboidalis* Hall and Whitfield, U. S. Geol. Expl., 40th Par., vol. 4, p. 253, pl. 4, fig. 4.
1888. *Strophomena rhomboidalis* Herrick, Bull. Sci. Lab. Denison Univ., vol. 4, pl. 9, fig. 6.
1889. *Strophomena rhomboidalis* Herrick, Am. Geol., vol. 3, pl. 4, fig. 6.
1892. *Leptæna rhomboidalis* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 13, fig. 9.
1892. *Leptæna rhomboidalis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 8, figs. 30-31; pl. 20, fig. 24.
1894. *Plectambonites rhomboidalis* Keyes, Mo. Geol. Surv., vol. 5, p. 70, pl. 39, fig. 6.

1895. *Strophomena rhomboidalis* Herrick, Geol. Surv. Ohio, vol. 7, pl. 20, fig. 6.
1899. *Leptæna rhomboidalis* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 525.
1904. *Leptæna rhomboidalis* Girty, Prof. Paper U. S. Geol. Survey, No. 21, p. 48, pl. 10, fig. 3.
1909. *Leptaena rhomboidalis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 292, pl. 12, figs. 2-3.

Description.—Shell of medium size or larger, subtrapezoidal in outline, wider than long, the greatest width along the hinge-line, the cardinal extremities angular, sometimes rather broadly auricular. The dimensions of a nearly complete example are: length 25 mm., width along hinge-line estimated 40 mm.

Pedicle valve depressed convex in the umbonal region, flattened anteriorly and laterally to near the margin of the valve where it is abruptly geniculate, the deflected portion variable in width with age, sometimes having a width equal to more than one-half the length of the flattened portion of the valve. The surface of the valve at the geniculate margin is sometimes raised in an elevated border which is highest in the median portion of the valve in front, becoming gradually reduced along the lateral margins anteriorly and becoming obsolete towards the cardinal extremities; the deflected border of the valve is sometimes sinuate in front, the sinus when present is broad, ill-defined, and shallow, and does not continue across the flattened portion of the valve; beak small, slightly or not at all extended beyond the cardinal margin, and not incurved, usually pierced by a minute, subcircular foramen which often becomes filled in mature shells; cardinal area narrow, flat or slightly concave, sloping posteriorly from the hinge-line and lying at an angle of 45 degrees or less to the plane of the valve, the lateral margins sharply defined; delthyrium broadly triangular, closed at its apex by a small deltidium, the greater portion of it filled by the cardinal process of the opposite valve. Internally the cardinal teeth are rather thick and short; near or a little posterior to the middle of the lateral margins, a rather narrowly elevated ridge passes posteriorly with a gentle curvature towards the middle of the hinge-line, the narrowly triangular areas toward the cardinal extremities, which are isolated by these ridges, are rather deeply excavated. The muscular scar is deeply concave, broader than long, subrhomboidal to subelliptical in outline, and is surrounded laterally and anteriorly by an angular ridge which terminates on either side just in front of the cardinal teeth; the length of the scar is one-third or less than one-third the total length of the valve, it is divided along its median line by a low angular ridge originating just within the anterior border and becoming obsolete towards the posterior border, on each side of this ridge are the narrow and elongate adductor scars, beyond which the much larger diductor scars occupy the greater portion of the total area; the primary trunk of the

vascular impressions originates at the anterior border of the muscular scar in the middle of the valve, it passes towards the anterior margin a short distance and divides into two lateral limbs which have a direction subparallel with the anterior and lateral margins of the valve, each lateral limb giving off branches at nearly right angles towards the margin of the valve, each branch divides into two or three before reaching the margin, and those in the anterior portion of the valve often anastomosing; between the two lateral limbs of the vascular markings and the muscular scars the inner surface of the valve is thickly papillose, with a few similar, but more scattered papillæ within the vascularly marked area.

Brachial valve slightly concave near the beak, becoming flattened or slightly convex to the line of geniculation of the pedicle valve, at which line the valve is abruptly deflected to conform with that valve; mesial fold entirely obsolete or represented by a slight, broad, low, ill-defined, longitudinal elevation across the deflected border of the valve; cardinal area narrower than that of the opposite valve and meeting it along the hinge-line in an angle of 45 degrees or less, the posterior extremity of the cardinal process protuberant at the middle of the cardinal area and surrounded by the chilidium. Internally a conspicuous, elevated, angular ridge follows the external line of deflection of the valve except near the cardinal margin, where its terminal portions curve towards the center of the valve; the ridge increases in prominence with age, and gives to that subelliptical portion of the valve bounded by it, a deeply concave contour; the external surface of the ridge slopes steeply to the margin of the valve except towards the cardinal extremities where it is deflected laterally; the cardinal process bifid; the muscular scars occupy a subrhomboidal area bordered by an elevated ridge and are divided by a median ridge; the vascular markings have an arrangement similar to those of the opposite valve; the surface sloping from the marginal ridge to the outer margin of the valve is marked by rather coarse, elongate papillæ irregularly arranged in radiating lines.

The surface markings of both valves consist of a series of conspicuous, concentric corrugations covering the flattened portions of the valves; these corrugations are variable in size upon the same individual, growing successively coarser from the beak to the margin, and also vary among different individuals, the minimum width being less than 1 mm. and the maximum 2 mm. or more; these wrinkles are often more or less discontinuous and sometimes divide or anastomose, and towards the cardinal extremities their direction is usually gradually deflected laterally; crossing the concentric wrinkles and continuing to the shell margin, are a series of fine, rounded, radiating costæ which increase by bifurcation and intercalation, about three or four of these usually occupying the space of one millimeter; the entire surface also marked by exceedingly fine concentric lines of growth.

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Remarks.—The shells here included in Phillip's species *L. analoga* have almost always been referred to the supposed long-lived species *L. rhomboidalis*. As set forth in the foregoing discussion of the genus *Leptæna*, it seems best to split up this so-called species into several groups of individuals which can conveniently be considered as distinct species. In our Mississippian faunas two such forms are recognized, of which the one here described is the more common. It is referred to Phillip's species because of its apparent identity with that species as illustrated by Davidson,[1] the original definition and figure of Phillips being too imperfect to allow of certain identification. The different individuals of the species exhibit some variation in the coarseness of the concentric corrugations of the shell and in the relative width of the anterior subtruncate margin and the consequent amount of divergence of the lateral margins of the shell, the finer corrugations and the more divergent lateral margins usually being associated.

Horizon.—Kinderhook and Lower Burlington.

Læptæna convexa n. sp.

Plate II, Figs. 11-16

1901. *Leptæna rhomboidalis* Weller, Trans. St. Louis Acad. Sci., vol. 11, pp. 159 and 180, pl. 14, figs. 19-20, and pl. 16, figs. 7-8.

Description.—Shell of medium size or somewhat larger, subsemicircular in outline, wider than long, the greatest width at or near the hinge-line, the cardinal extremities usually nearly rectangular. The dimensions of a nearly complete pedicle valve are: length 21 mm., greatest width 28 mm., convexity 8 mm.

Pedicle valve depressed convex in the umbonal region, this convexity continuing for two-thirds or more of the length of the shell, beyond which it curves more abruptly to the anterior and lateral margins, the surface somewhat compressed towards the cardinal extremities, mesial sinus wanting; beak small, scarcely produced beyond the cardinal margin and not incurved, perforated at its apex by a small, circular foramen which sometimes becomes filled in mature shells; cardinal area narrow. Internal characters of the valve not observed.

Brachial valve gently concave posteriorly, becoming more strongly curved towards the lateral and anterior margins with no suggestion of a mesial fold or sinus, somewhat flattened towards the cardinal extremities. Internal characters of the valve not observed.

The surface markings of both valves consist of concentric corrugations which cover the more gently curved posterior portion, these corrugations being either quite regular in their development or exhibiting a con-

[1] Mon. Brit. Carb. Brach., p. 119, pl. 28, figs. 1-13 (1860).

siderable amount of irregularity; they are narrower and less deeply impressed towards the beak, becoming regularly stronger distally; fine radiating costæ cross the concentric corrugations and continue to the shell margin, from three to five occupying the space of one millimeter, and these costæ are again crossed by still finer concentric markings.

Remarks.—This species differs from *L. analoga* in the absence of the distinctly flattened posterior region which passes into the anterior and antero-lateral border by an abrupt geniculate deflection of the valves; instead of this the valves are more regularly curved throughout, the surface curving somewhat more rapidly towards the margin instead of being abruptly deflected. Upon this species the fine radiating costæ are also more strongly and more regularly developed, although no broader; the concentric corrugations are less deeply impressed and a little less regular in their development, and the fine concentric markings are more conspicuous. In their occurrence the two species are not associated together in the same fauna, and the present species is less commonly seen than is *L. analoga.*

Horizon.—Kinderhook.

Genus *SCHUCHERTELLA* Girty

Description.—Shell biconvex, hinge-line usually equaling or sometimes a little shorter than the greatest width, the lateral and anterior margins rounded. Pedicle valve with a moderately high cardinal area, with a large delthyrium which is closed to the apex by the deltidium. The cardinal area is differentiated into two regions, the outer or primary area and the inner or secondary area slightly raised above the former, the lines separating the two regions pass from the apex of the beak to points about midway between the delthyrium and the cardinal extremities upon the hinge-line; the entire area is marked by horizontal lines of growth in addition to which the secondary area is marked by vertical striæ which become more noticeable with the wearing of the surface. Internally the dental lamellæ are reduced to mere thickenings of the inner surface of the cardinal area at the margins of the delthyrium; a median septum is absent. The brachial valve is a little less convex than the pedicle valve, with a narrow cardinal area, and a short cardinal process.

Remarks.—The genus *Schuchertella*, as originally proposed by Girty for those non-septate orthotetoid shells which Hall and Clarke referred to *Orthothetes,* includes two distinct generic types, as has been pointed out by Thomas.[1] The first of these, *Schuchertella* proper, as typified by the genotype *S. lens,* includes the lesser number of the Mississippian species, the second and larger group of species being designated by the

[1] Mem. Geol. Surv. Gt. Brit., Paleontology, vol. 1, pt. 2, p. 92 (1910).

generic name *Schellwienella*. The most essential characters of *Schuchertella* are the biconvex shell and the undeveloped dental plates. The last of these characters cannot always be detected in the specimens studied, but so far as has been observed these two characters are always associated.

Schuchertella fernglenensis n. sp.

Plate III, Figs. 12-13

1909. *Orthothetes rubra* Weller, Bull. Geol. Soc. Am., vol. 20, pl. 12, fig. 4 (not fig. 5).

Description.—Shell above medium size, biconvex, broader than long, the hinge-line a little less than the greatest width of the shell, in mature examples the cardinal extremities obtusely angular. The dimensions of the holotype are: length 35.5 mm., greatest width 52 mm., length of hinge-line about 42 mm., height of cardinal area 6 mm.

Pedicle valve very gently convex, most prominent in the umbonal region, sloping with a very gentle curvature to the anterior and lateral margins, very slightly or not at all flattened towards the cardinal extremities; mesial sinus absent; beak blunt, not incurved, cardinal area flat, with sharply defined lateral margins, sloping posteriorly from the hinge-line; delthyrium broadly triangular, broader than high, closed by a convex deltidium with a sinuate cardinal margin.

Brachial valve aparently somewhat less convex than the pedicle, with the surface flattened towards the cardinal margin.

Surface of both valves marked by narrow, subangular costæ, which increase by implantation, the intercostal spaces being wider than the costæ themselves, one or two costæ occupying the space of one millimeter. The costæ are crossed by rather strong, irregularly developed, concentric lines of growth. Very fine concentric markings are faintly indicated on some portions of the shell and probably covered both valves when in a perfect condition.

Remarks.—The holotype of this species is a specimen preserving both valves which have been somewhat crushed longitudinally. It was at first thought to be an example of *S. rubra*, and was originally illustrated as such, but the difference in the character of the radiating costæ is so marked that it is now described as the type of a distinct species. Besides the difference in the radiating costæ, the specimen is considerably larger than any example of *S. rubra* which has been studied. The internal characters of neither valve have been observed, and the cardinal margin of the brachial valve has been pushed in behind the cardinal area of the pedicle valve in such a manner as to hide the characters of that portion of that valve. It is believed that the most important distinguishing character of the species, by means of which it may be separated from

other members of the genus, is to be found in the comparatively narrow costæ separated by broad intercostal spaces.

Horizon.—Fern Glen formation.

Schuchertella lens (White)

Plate III, Figs. 1-8, 9?

1862. *Streptorhynchus lens* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 28.
1892. *Orthothetes lens* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 16, figs. 12-16.
1892. *Orthothetes lens* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 11A, figs. 16-22.
1894. *Streptorhynchus lens* Keyes, Mo. Geol. Surv., vol. 5, p. 67, pl. 39, figs 2a-b.
1904. *Schuchertella lens* Girty, Proc. U. S. Nat. Mus., vol. 27, p. 734.
1908. *Orthothetes lens* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 78, pl. 17, figs. 37-42.

Description.—Shell small, lenticular in form, broader than long, the greatest width near the mid-length of the shell, the hinge-line usually a little shorter than the greatest width, the cardinal extremities angular. The dimensions of two individuals are: length of pedicle valve 14.3 mm. and 14.7 mm., length of brachial valve 12.9 mm. and 13.1 mm., greatest width 16.8 mm. and 17 mm., length of hinge-line 14.7 mm. and 13 mm., thickness 6 mm. and 5.5 mm., height of cardinal area 3.8 mm. and 2.5 mm.

Pedicle valve depressed convex, most prominent in the umbonal region, the surface sloping with a gently convex curvature to the lateral and anterior margins, not at all or only very slightly depressed towards the cardinal extremities; mesial sinus obsolete; beak obtusely pointed, not incurved; cardinal area nearly flat, with sharply defined lateral margins, sloping posteriorly from the hinge-line at an angle between 115 and 125 degrees to the plane of the valve; delthyrium broadly triangular, as broad or broader than high, closed by a rather strongly convex deltidium which is deeply concave along its cardinal margin. Internally the apical portion of the valve is more or less solidified, the cardinal teeth are unsupported by dental plates, although the inner surface of the valve is thickened along each side of the delthyrium; the muscular scars are of moderate size, subovate in outline with their anterior margin lying posterior to the middle of the valve, the central adductor scars are variable in their differentiation, sometimes being only faintly defined and again being sharply defined and sometimes raised anteriorly above the level of the diductor scars on either side; the inner margin of the valve is crenulated laterally and anteriorly.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the surface compressed towards the cardinal ex-

tremities and gently convex from the beak towards the lateral and anterior margins, the umbo not protuberant beyond the cardinal margin; the mesial portion of the valve usually somewhat flattened from the beak to the front margin, sometimes slightly depressed to form a very shallow, ill-defined sinus; the cardinal area very narrow with sharply defined lateral margins, forming an obtuse angle with that of the opposite valve. Internally the cardinal process is short and rather thick, bifid posteriorly, with a chilidium adjacent to the cardinal margin which occupies the concavity in the base of the deltidium of the opposite valve; from either side of the cardinal process the socket plates or ridges diverge and are then recurved to the cardinal margin to form the sockets; the muscular scars subovate in outline, reaching beyond the middle of the valve and more deeply impressed than those of the opposite valve, sometimes divided longitudinally by a rather broad, slightly raised median ridge which continues to the base of the cardinal process.

Surface of both valves marked by sharp, narrow, radiating costæ which increase by bifurcation and intercalation, about three occupy the space of one millimeter at the front of mature shells. The costæ are crossed by fine concentric markings, when the surface is well preserved, which give them a crenulated appearance, and by much stronger concentric lines of growth which are not infrequently crowded towards the front of the shell.

Remarks.—This species has been selected by Girty[1] as the type of his genus *Schuchertella*. It is a very characteristic member of the Louisiana limestone fauna, and never attains a large size, the largest individual observed by the writer having a length of 16 mm.

Horizon.—Louisiana limestone.

Schuchertella rubra Weller

Plate III, Figs. 10-11

1909. *Orthothetes rubra* Weller, Bull. Geol. Soc. Am., vol. 20, p. 294, pl. 12, fig. 5 (not fig. 4).

Description.—Shell of medium size or a little larger, biconvex, broader than long, the greatest width near the mid-length, the hinge-line straight, a little shorter than the greatest width, the cardinal extremities angular, the central portion of the anterior margin nearly straight or slightly emarginate. The dimensions of a somewhat crushed specimen preserving both valves are: length of pedicle valve 25.3 mm., length of brachial valve 24 mm., greatest width 36 mm., length of hinge-line 32 mm., thickness approximately 10 mm., height of cardinal area approximately 3 mm.

Pedicle valve gently convex, greatest convexity posterior to the middle,

[1] Proc. U. S. Nat. Mus., vol. 27, p. 734 (1904).

the surface slightly compressed towards the cardinal extremities; median portion of the valve a little flattened anterior to the middle but not depressed in a mesial sinus; beak apparently obtusely angular, but slightly protuberant beyond the cardinal margin; cardinal area rather low, apparently flat and lying nearly at a right angle to the plane of the valve, the lateral margins sharply defined and angular, sloping in nearly straight or slightly concave lines from the beak to the cardinal extremities; the delthyrium broadly triangular, its apical portion closed by a convex deltidium. Internally the dental plates are apparently obsolete; the flabellate muscular scars are of medium size, but are illdefined and only slightly impressed.

Brachial valve about equally convex with the pedicle, but with the greatest convexity situated farther towards the front, apparently anterior to the middle in the type specimen, the surface compressed towards the cardinal extremities, the umbonal region flattened; the mesial portion of the valve depressed in a shallow and rather broad, ill-defined mesial sinus; the beak inconspicuous. Internal characters not observed, although the posterior extremity of a rather broad cardinal process is exhibited in the type specimen.

Surface of both valves marked by fine, subangular, radiating costæ which are slightly irregular in size, separated by rather deep intercostal furrows, about three occupying the space of 1 mm. Crossing the costæ are fine, concentric markings which seem to be more conspicuous towards the cardinal extremities, in which portion of the shell the radiating costæ are minutely serrate by reason of the crossing of the concentric lines. A few rather faint concentric lines of growth are present upon the body of the shell, but in old examples they become very strong near the margins of the valves.

Remarks.—This species resembles *S. lens* from the Louisiana limestone, but it attains a much larger size, is proportionally broader, and is marked by somewhat finer radiating costæ. The smaller, immature examples of about the average size of *S. lens* may be distinguished from that species by their form and costæ.

Horizon.—Fern Glen formation.

SCHUCHERTELLA COSTATULA (Hall and Clarke)

Plate II, Figs. 19-22

1892. *Derbya (?) costatula* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, p. 346, pl. 11B, figs. 16-17.

1897. *Derbya (?) costatula* Hall, 14th Ann. Rep. N. Y. State Geol., p. 346, pl. 5, fig. 9.

Description.—Shell small, broader than long, the hinge-line as long or nearly as long as the greatest width of the shell, the cardinal extremities angular. The dimensions of the holotype are: length of pedicle valve

12 mm., length of brachial valve 9.6 mm., greatest width 12.4 mm., length of hinge-line 10.8 mm., height of cardinal area, 2.8 mm., thickness 5.6 mm.

Pedicle valve somewhat distorted, moderately convex, most prominent posteriorly, the surface a little compressed towards the cardinal extremities, with no mesial sinus; the beak pointed, extending conspicuously beyond the cardinal margin posteriorly; cardinal area of moderate height, flat, inclined posteriorly, the lateral margins sharply defined and angular, sloping in nearly straight, slightly concave or slightly convex lines from the beak to the cardinal extremities; the delthyrium broadly triangular, closed by a convex deltidium. Internally the hinge-teeth are supported by short dental lamellæ, no median septum present.

Brachial valve rather strongly convex, the greatest convexity near the middle, compressed towards the cardinal extremities; the umbonal region prominent, but not protuberant posteriorly beyond the cardinal margin, the surface curvature more gentle towards the lateral and anterior margins.

The surface markings of both valves consist of a series of rather strong radiating costæ from one to two millimeters apart, which originate in the umbonal region and which are absent towards the cardinal extremities, between the coarser costæ and extending to the cardinal extremities, the surface is covered by much finer radiating costæ. The surface also marked by regular, concentric lines of growth of moderate strength.

Remarks.—This species was originally described as a member of the genus *Derbya,* with a query, by Hall and Clarke. The holotype of the species shows neither the presence or absence of a median septum in the pedicle valve, but another specimen, a pedicle valve with a perfectly clean interior, from the same locality as the holotype, shows conclusively that no such septum is present. The dental lamellæ in the same specimen are better developed than in the typical *Schuchertella* where they are reduced to mere thickenings of the inner surface of the valve along the margins of the delthyrium, being distinct plates, although very short. In this character, then, the species resembles the members of the genus *Schellwienella,* but it does not possess the resupinate form of typical members of that genus. The species is, therefore, intermediate in its characters between these two genera, and is placed in *Schuchertella* somewhat arbitrarily.

The species is especially characterized by the strong radiating costæ which occur at intervals, with the much finer ones between. Occasionally specimens of the truly septate *Orthotetes kaskaskiensis* exhibit this same characteristic, though not to such a conspicuous degree, but that species is always a much larger shell in its adult condition, than the largest examples of *S. costatula* which have been observed.

Horizon.—Chester group.

Genus *SCHELLWIENELLA* Thomas

Description.—Shell resupinate, the pedicle valve flat or concave, the brachial valve convex, the hinge-line equaling, less than or greater than the greatest width of the shell in front, the lateral and anterior margins rounded. Cardinal area of the pedicle valve variable in height, differentiated into a primary and a secondary area as in *Schuchertella*, and with the deltidium closing the delthyrium to the apex. Internally the dental lamellæ are short and rather widely divergent, and a median septum is absent. The brachial valve is convex, often strongly so, with no cardinal area.

Remarks.—*S. inflata* may be considered as a typical American representative of this genus, it being a species in which both the resupinate shell and the short and widely divergent dental lamellæ have been clearly recognized, these two characters being the essential features by means of which members of this genus may be differentiated from *Schuchertella*. In practice the resupinate form of the shell, viz., the concave pedicle valve, will doubtless be most commonly used for distinguishing the genus. Among the examples studied in which the characters of the dental lamellæ can be determined there seems to be some variation in the strength of their development, in some instances these lamellæ being but little or not at all different from those of *Schuchertella*. The two genera are closely allied and it is not surprising that there should be a more or less complete intergradation in the character of the dental lamellæ, but in no case among the specimens here studied has there been any hesitation as to the genus in which any one should be placed on the basis of the form of the pedicle valve.

SCHELLWIENELLA INFLATA (White and Whitfield)

Plate IV, Figs. 7-12; Plate LXXXIII, Fig. 11

1862. *Streptorhynchus inflatus* White and Whitfield, Proc. Boston Soc. Nat. Hist., vol. 8, p. 293.
1877. *Streptorhynchus inflatus* Hall and Whitfield, U. S. Geol. Expl., 40th Par., vol. 4, p. 253, pl. 4, fig. 3.
1883. *Streptorhynchus æquivalvis* Hall, Rep. N. Y. State Geol., for 1882, pl. (11A) 42, figs. 24, 25.
1892. *Orthothetes inflatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 9A, figs. 24, 25.
1901. *Orthothetes inflatus* Weller, Trans. St. Louis Acad. Sci., vol. 11, pp. 181 and 195, pl. 16, figs. 2-3, and pl. 19, figs. 10-12.

Description.—Shell concavo-convex, of medium size or larger, usually subelliptical in outline and broader than long with the greatest width near or posterior to the mid-length, the hinge-line a little shorter than the greatest width, the cardinal extremities obtusely angular or a little rounded. The dimensions of a nearly complete example, one of the co-

types of the species, which is exceptionally elongate in form, are: length of pedicle valve 28.5 mm., length of brachial valve 27.3 mm., greatest width 27.8 mm., length of hinge-line 26 mm., height of cardinal area 8.7 mm., convexity of brachial valve 14 mm. The dimensions of a detached brachial valve from the typical locality are: length 25.6 mm., width 33 mm., length of hinge-line ±30 mm., convexity 10 mm.

Pedicle valve concave in general contour with the surface flattened or slightly convex towards the cardinal extremities and the umbonal region slightly convex over a small area, the greatest concavity near or anterior to the middle; mesial sinus obsolete; beak small, pointed, nearly erect, sometimes a little distorted or recurved; cardinal area of moderate height in the only specimen in which it has been observed, convex from the cardinal margin to the apex with the lower portion sloping posteriorly from the hinge-line at an angle of about 110 degrees, the lateral margins sharply angular, sloping from the beak to the cardinal extremities in slightly flexuous lines due to the distortion of the beak, the delthyrium narrowly triangular, much higher than wide.

Brachial valve strongly convex, the greatest convexity near or posterior to the middle, the umbonal region prominent and usually somewhat protuberant posteriorly beyond the hinge-line, the surface curving more abruptly from the point of greatest convexity to the cardinal margin and a little more gently to the lateral and anterior margins, compressed and somewhat auriculate towards the cardinal extremities; mesial portion of the valve not differentiated; beak inconspicuous.

Surface of both valves marked by fine, narrowly rounded or subangular costæ, somewhat irregular in size, from two to four occupy the space of one millimeter. Concentric markings of the shell inconspicuous; in no case is the surface of the shell preserved so as to show the minute markings, and the stronger lines of growth are limited to a few more or less inconspicuous, wrinkle-like markings which are often nearly or quite obsolete.

Remarks.—The types of this species are mostly from the uppermost, magnesian limestone layer of the Kinderhook, at Burlington, Iowa, although some examples from the Kinderhook oolite of the same locality are included in the type lot. The only specimen retaining both valves in articulation is from the magnesian limestone layer and it is from that bed that the most of the specimens in more recent collections have been secured. The specimens most commonly found, both at the type locality and elsewhere, are detached brachial valves. The only specimen retaining both valves in articulation which has been observed, and the only one in which the length is greater than the width, is one of the types already mentioned, it alone has been the source of the description of the pedicle valve given above; not enough specimens have been examined to determine whether or not the beak is commonly distorted as in that specimen, or whether

the cardinal area is commonly convex. An internal cast of a pedicle valve from the same horizon and locality, probably a member of this species, does not have a distorted beak and has a flat cardinal area which slopes posteriorly from the hinge-line at an angle of about 115 degrees; it also shows the presence of short but distinct dental plates and a scarcely defined, flabellate muscular scar.

The pedicle valve of this species, so far as it has been observed, resembles that of *S. planumbona*, but it is probably more often distorted at the beak than that species and usually has more conspicuous lines of growth. It is probably true, however, that some specimens of the pedicle valve of *S. planumbona* were included by White and Whitfield among the types of this species. The brachial valves of the two species are entirely different, the umbonal region of this one being very prominent and somewhat protuberant beyond the cardinal margin, while the same region in *S. planumbona* is very gently convex, the slope to the anterior margin of the shell being more abrupt than that to the cardinal margin.

Horizon.—Kinderhook.

Schellwienella inæqualis (Hall)

Plate III, Figs. 14-16

1858. *Orthis inequalis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 490, pl. 2, figs. 6a-c.
1865. *Streptorhynchus inequalis* Winchell, Proc. Acad. Nat. Sci., Phil., p. 117.
1870. *Hemipronites inequalis* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 251.
1877. *Streptorhynchus equivalvis* Hall and Whitfield, U. S. Geol. Expl., 40th Par., vol. 4, p. 252, pl. 4, figs. 1, 2.
1883. *Streptorhynchus æquivalvis* Hall, Rep. N. Y. State Geol. for 1882, pl. (11A) 42, figs. 20-23.
1892. *Orthothetes inæqualis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 9A, figs. 20-23.
1899. *Orthothetes inæqualis Girty,* Mon. U. S. Geol. Survey, vol. 32, p. 522, pl. 68, fig. 3a.
1900. *Orthothetes inæqualis* Weller, trans. St. Louis Acad. Sci., vol. 10, p. 66, pl. 1, fig. 18.
1901. *Orthothetes inæqualis* Weller, Trans. St. Louis Acad. Sci., vol. 11, pp. 159 and 195, pl. 14, figs. 16-18, and pl. 19, fig. 9.
1903. *Orthothetes inæqualis* Girty, Prof. Paper U. S. Geol. Survey No. 16, p. 276.

Description.—Shell concavo-convex, of about medium size, wider than long, the greatest width near or in front of the mid-length, the hinge-line a little shorter than the greatest width, the cardinal extremities angular. The dimensions of a large, nearly complete pedicle valve are: length 23.7 mm., greatest width 31.4 mm., length of hinge-line 30 mm. The dimensions of a brachial valve are: length 18.5 mm., width 22 mm., length of hinge-line 18.5 mm., convexity 6.5 mm.

Pedicle valve nearly flat throughout in immature specimens, becoming concave as it approaches maturity, the curvature beginning at a little more than two-thirds the length of the shell from the beak in the specimen whose dimensions are given above, towards the cardinal extremities the surface is very gently convex as it approaches the cardinal margin; mesial sinus obsolete; the beak inconspicuous, in the internal casts scarcely extended beyond the straight or nearly straight cardinal margin of the valve; cardinal area narrow, lying at nearly a right angle to the plane of the valve, the lateral margins angular, the two sides of the beak being in nearly a straight line; the delthyrium broadly triangular. Internally the hinge-teeth are supported by thickened ridges on the inner surface along each margin of the delthyrium, which can scarcely be designated as dental plates; the muscular scars obscure or poorly defined.

Brachial valve rather strongly convex, the greatest convexity posterior to the middle, the surface curving more abruptly towards the cardinal margin, the cardinal extremities compressed and subauriculate, the umbonal region prominent and projecting somewhat beyond the cardinal margin; the mesial portion of the valve flattened or depressed in a shallow, ill-defined sinus which in the casts is better developed near the beak; the beak not conspicuous, somewhat incurved. Internal characters not well exhibited in any of the specimens.

Surface of both valves marked by radiating costæ which, on the casts, are subangular and irregular in size, although not distinctly alternating, those of the pedicle valve being more regular than those of the brachial, from two to four occupying the space of 1 mm. at the margin of the valves; the costæ are apparently more numerous at the margin than further back, the additional ones being added close to the margin and being in the nature of crenulations of the inner margin which would not be shown on the external surface, rarely more than two in the space of 1 mm. at the margin on the outside. The costæ are crossed by concentric lines of growth which are usually restricted to the region near the margin.

Remarks.—This species is known only from specimens preserved as internal casts in a fine-grained yellow sandstone, which do not preserve the minute surface markings. In no case have the two valves been seen in articulation, but the pedicle and brachial valves here described occur in such association as to make it almost certain that they are parts of the same species. The species is especially characterized by the slight mesial sinus in the brachial valve, by the flatness of the pedicle valve to near the margin where the concavity begins, and by the straight cardinal margin of the pedicle valve and narrow cardinal area.

Horizon.—Kinderhook.

SCHELLWIENELLA CRENULICOSTATA n. sp.

Plate III, Figs. 17-18

Description.—Shell concavo-convex, a little above medium size, broader than long, the greatest width near or posterior to the mid-length, the hinge-line a little shorter than the greatest width, the cardinal extremities angular. The dimensions of a very perfect pedicle valve are: length 25.8 mm., greatest width 35 mm., length of hinge-line 30 mm., height of cardinal area 2.6 mm.

Pedicle valve concave, the greatest concavity near the middle, the surface flattened towards the cardinal extremities, a small umbonal region rather abruptly elevated from the general surface; mesial sinus obsolete; the beak small, nearly erect; cardinal area narrow, lying at nearly a right angle to the plane of the valve, the lateral margins sharply defined, nearly straight or gently convex from the cardinal extremities nearly to the beak, where they become concave and curve up rather abruptly to the apex of the valve, the lateral margins on the two sides of the beak lying in essentially a straight line; delthyrium broadly triangular, twice or more than twice as wide as high with a convex deltidium closing the apical portion. Internally a pair of widely divergent hinge-teeth of moderate size are present; the other internal characters not observed but the dental plates are probably restricted to ridge-like thickenings of the inner surface of the shell at each side of the delthyrium.

Brachial valve not observed.

Surface of the shell marked by fine, uniform, regularly dividing, rounded costæ, about four or sometimes five of which occupy the space of 1 mm., with the intercostal furrows narrower than the costæ. Crossing the costæ there are fine, concentric markings, becoming more conspicuous beyond the middle of the valve where they divide the summits of the radiating costæ into a series of crenulations. Besides the fine concentric markings there are a few much stronger, concentric lines of growth which are more conspicuous towards the outer margin.

Remarks.—This species has been described almost exclusively from a very perfect pedicle valve from the Kinderhook oolite at Burlington, Iowa, but it is recognized also, from the pedicle valve alone, in the subjacent yellow sandstone at the same locality. In general outline the shell is not greatly different from *S. inflatus* or *S. inæqualis*. It differs from both these species in the size and form of the radiating costæ. The pedicle valve of the species may be distinguished from that of *S. inflatus* by its much narrower cardinal area, by the nearly straight line formed by the two lateral margins of the area, and by the small, abruptly elevated umbonal region of the valve. From *S. inæqualis* the species differs, in addition to the different character of the costæ, in the greater concavity

of the pedicle valve, the concavity being distributed through the entire length of the valve, and in the abruptly elevated umbonal region; the two species are similar in their narrow cardinal areas, the two lateral margins of which form nearly a straight line.

Horizon.—Kinderhook.

Schellwienella chouteauensis n. sp.

Plate VII, Figs. 5-8

Description.—Shell of medium size or a little larger, broader than long, the hinge-line nearly or quite equaling the greatest width, the cardinal extremities angular, the lateral margins nearly straight or gently convex posteriorly, becoming more convex anteriorly and rounding without interruption into the convex anterior margin. The dimensions of a nearly complete specimen are: length of pedicle valve 23 mm., length of brachial valve 21 mm., greatest width 27.5 mm., length of hinge-line 24.5 mm., convexity of brachial valve 4.8 mm., height of cardinal area 3.8 mm.

Pedicle valve concave or sometimes nearly flat, most prominent on the umbo which is raised above the remaining surface of the valve; mesial sinus obsolete; beak obtusely angular, erect; cardinal area of moderate width, flat, with sharply angular lateral margins which slope from the beak to the cardinal extremities in nearly straight lines; the delthyrium wider than high, closed by a convex deltidium with a concave cardinal margin. Internal characters not observed.

Brachial valve moderately convex, the greatest convexity posterior to the middle, the surface curving gently from the highest point to the lateral and anterior margins, a little more abruptly to the cardinal margin, somewhat compressed towards the cardinal extremities; mesial fold obsolete; beak inconspicuous, not extended beyond the cardinal margin; cardinal area very narrow, making an obtuse angle with that of the opposite valve, the middle of the hinge-line marked by the rather prominent posterior extremity of the cardinal process which fills the concave cardinal excavation of the deltidium of the opposite valve. Internal characters not observed.

Surface of both valves marked by rather coarse radiating costæ which are similar on the two valves, about two occupying the space of one millimeter. The costæ are crossed by regular, strong, irregularly distributed, concentric lines of growth which are commonly more crowded towards the front of the shell.

Remarks.—This species from the Chouteau limestone is perhaps more closely similar to *S. inæqualis* than to any other species of the genus here considered, but it is a more coarsely costate shell than that one.

Horizon.—Chouteau limestone.

SCHELLWIENELLA PLANUMBONA n. sp.

Plate III. Figs. 19-22

1901. *Orthothetes* sp. Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 181, pl. 16, fig. 1.

Description.—Shell above medium size, subelliptical in outline, usually perfectly symmetrical, broader than long, the greatest width near the mid-length, the hinge-line a little shorter than the greatest width, the cardinal extremities angular. The dimensions of two nearly complete pedicle valves are: length 39.5 mm. and 31 mm., width 49 mm. and 38 mm., length of hinge-line 40 mm. and 34.2 mm., height of cardinal area 7.8 mm. and 5.8 mm. The dimensions of an imperfect brachial valve are: length 28 mm., width 31 mm., length of hinge-line 28 mm., convexity 8.5 mm.

Pedicle valve concave in general contour, with the small umbonal region depressed convex, and the surface towards the cardinal extremities flattened or gently convex; mesial sinus obsolete; the beak obtusely pointed, inclined posteriorly; cardinal area flat, of moderate height, sloping posteriorly from the hinge-line at an angle of about 110 degrees, the lateral margins sharply angular, sloping in nearly straight lines from the beak to the cardinal extremities; the delthyrium about as wide or a little wider than high, its apical portion covered by a strongly convex deltidium which does not reach much beyond the mid-height of the area, the lower portion apparently being occupied by the posterior extremity of the cardinal process of the opposite valve. The internal features of the valve are not well shown in any of the specimens, but the dental plates seem to be poorly developed, being little more than thickened ridges on each side of the delthyrium; the muscular scars apparently ill-defined; the inner surface of the valve crenulate along the lateral and anterior margins.

Brachial valve convex with the greatest convexity near or anterior to the middle; the surface curving gently from the highest point to the cardinal margin and more abruptly to the anterior and antero-lateral margins, the umbonal region flattened or depressed-convex, the surface compressed towards the cardinal extremities; mesial portion of the valve not differentiated; the beak inconspicuous, not extended beyond the cardinal margin. Internal features of the valve not observed.

Surface of both valves marked by fine, rounded, radiating costæ which increase by bifurcation and by implantation, from two to four occupying the space of one millimeter. Distinct concentric lines of growth are not commonly present upon either valve.

Remarks.—This species is the most common form of the genus occurring in the Kinderhook oolite at Burlington, Iowa. It is especially character-

ized by the form of the brachial valve which has its greatest convexity farther forward than is usual in members of the genus, so that the curvature to the anterior margin is somewhat more abrupt than to the hinge-line. The pedicle valve resembles that of *S. inflatus,* but the beak seems to be more depressed, the brachial valves of the two species, however, are very different. The usual absence of concentric growth lines is a noticeable character of the species. The two valves have not been observed in articulation, but both occur in such close association in the limestone as to leave no doubt as to their being parts of the same species.

Horizon.—Kinderhook.

Schellwienella alternata n. sp.

Plate IV, Fig. 6

Description.—Shell rather large, broader than long, the hinge-line a little shorter than the greatest width, the cardinal extremities angular. The dimensions of a nearly complete brachial valve are: length 41.5 mm., width 57 mm., length of hinge-line 51.5 mm., convexity 11.8 mm.

Pedicle valve not observed.

Brachial valve convex, the greatest convexity anterior to the middle, the surface curving with a more abrupt slope to the front margin than to the cardinal margin, compressed and subauricular towards the cardinal extremities, the umbonal region depressed convex or nearly flat; the mesial portion of the valve somewhat flattened from the beak to the front margin but not distinctly differentiated from the general curvature of the surface; the beak inconspicuous, not produced beyond the cardinal margin.

Surface of the shell marked by a series of stronger, rounded, radiating costæ, averaging a little less than 1 mm. apart at the shell margin, alternating with which there are usually very much finer and more angular costæ. The costæ are crossed by fine, concentric markings which are stronger in the intercostal furrows, being nearly obsolete on the summits of the costæ. A few stronger concentric lines of growth are also present at intervals.

Remarks.—This species is based upon a single, nearly complete brachial valve, no pedicle valve having been found which can be associated with it. This valve somewhat resembles *S. planumbona* in its distinctly flattened umbonal region, but it is proportionally broader, besides having distinctly different surface markings. The distinctly alternating costæ with the concentric markings stronger in the intercostal furrows are characters not shared with any other species of the genus here described.

In the absence of the pedicle valve it is not possible to determine certainly the true generic relations of this species, and it may eventually prove to be a member of the genus *Schuchertella.* The species has been

placed in *Schellwienella* because its relationships seem to be closer to *S. planumbona* than to any other species, and that form has been definitely established as being one of the more typical members of the genus *Schellwienella* in our faunas.

Horizon.—Burlington limestone.

Schellwienella burlingtonensis n. sp.

Plate IV, Figs. 1, 2

Description.—Shell large, subsemielliptical in outline, wider than long, the greatest width along the hinge line, the cardinal extremities angular and semiauriculate, the lateral margins gently concave in front of the cardinal extremities, becoming gently convex anteriorly and then curving without interruption into the anterior margin which, with the convex portions of the lateral margins, is nearly semicircular. The dimensions of a pedicle valve are: length 64.5 mm., width along hinge-line 90 mm., height of cardinal area 21.5 mm. The dimensions of a brachial valve are: length 47 mm., width along hinge line ±65 mm.

Pedicle valve gently concave along a line from the beak to near the front margin, beyond which it becomes convex, the surface nearly flat towards the cardinal extremities and convex in a comparatively narrow marginal band along the lateral and anterior margins, most prominent in the umbonal region close to the cardinal margin; mesial sinus obsolete; the beak erect, very broadly obtuse; cardinal area high and flat, sloping posteriorly from the hinge-line at an angle of about 120 degrees to the plane of the valve, the lateral margins sharply angular, sloping from the beak to the cardinal extremities in a convex curve which is gentle until it approaches the extremities where it becomes much more abrupt; the delthyrium higher than wide, closed by a deltidium. Internal characters not observed.

Brachial valve convex, the greatest convexity probably near the middle, the surface compressed towards the cardinal extremities, the umbo a little prominent but not protuberant beyond the cardinal margin; mesial fold obsolete; beak scarcely differentiated, not extending beyond the cardinal margin. Internal characters not observed beyond the posterior extremity of the cardinal process which is large, about twice as wide as high, and deeply bifid.

Surface of both valves marked by regular, rounded, radiating costæ about two of which occupy the space of one millimeter near the margin of a mature shell. The costæ are crossed by more or less regular concentric lines of growth of varying strength which become more crowded towards the outer margin.

Remarks.—This species has been established upon two specimens, one pedicle and one brachial valve. Both are from the Burlington limestone of Henderson County, Illinois, and were apparently found in association, although they are not the opposite valves of a single specimen. Both valves are imperfect in several particulars, although their outlines are well shown, and the brachial valve has been considerably crushed. In neither specimen are the internal characters shown except very imperfectly, so it cannot be stated with absolute certainty that no median septum is present in the pedicle valve, but the shell is exfoliated and partially removed in the umbonal region of the specimen and there seems to be no such structure present. In this specimen the muscular scar is partially exposed; it seems to be large and flabellate, reaching beyond the middle of the valve. The marginal convexity of the pedicle valve, which has been described, is doubtless due to old age of the specimen, and in younger examples the surface would doubtless be concave from the beak to the front margin. The species is somewhat similar to the one which has been here described as *S. choutcauensis,* but it is very much larger besides having its greatest width along the hinge-line, having subauriculate cardinal extremities.

Horizon.—Burlington limestone.

Genus *STREPTORHYNCHUS* King

Description.—Shell biconvex, usually subglobose in form, the pedicle valve or both valves more or less distorted and irregular in manner of growth, the hinge-line shorter than the greatest width of the shell. Cardinal area of the pedicle valve variable in height, differentiated into a primary and a secondary area as in *Schuchertella*, the delthyrium closed to its apex with the deltidium. Internally the pedicle valve is nonseptate, the dental lamellæ are reduced to ridges which are merely thickenings of the inner surface of the cardinal area at the sides of the delthyrium, the condition being essentially as in *Schuchertella;* in the brachial valve the cardinal process is elongate and deeply grooved, its length being dependant upon the convexity of the umbonal region of the pedicle valve.

Remarks.—The genus *Streptorhynchus,* as interpreted by Hall and Clarke,[1] Girty,[2] and Thomas,[3] based upon *S. pelargonatus* Schl., as the genotype, is characterized as follows: 1, the general form of the shell; 2, the absence of true dental lamellæ; 3, the absence of a median septum in the pedicle valve; 4, the elongate, deeply grooved cardinal process. From *Orthotetes* the genus differs conspicuously in the absence of the

1 Pal. N. Y., vol. 8, pt. 1, p. 267 (1894).
2 The Gaudalupian Fauna, p. 175 (1908).
3 Mem. Geol. Surv. Gt. Brit., vol. 1, pt. 2, p. 89 (1910).

median septum of the pedicle valve, from *Schellwienella* it may be distinguished at once by its biconvex shell and its irregular manner of growth, its closest relationship being with *Schuchertella*. In both *Streptorhynchus* and *Schuchertella* the median septum of the pedicle valve is absent, as are also true dental lamellæ, leaving then only the greater convexity of the valves, their irregular manner of growth, the shorter hinge-line and the form of the cardinal process as diagnostic characters of *Streptorhynchus*. The distortion of the valves in *Streptorhynchus*, especially the pedicle valve, is due to the attachment of the shell by the apex of that valve, while *Schuchertella* is unattached.

STREPTORHYNCHUS TENUICOSTATUM n. sp.

Plate IV, Figs. 3-5

Description.—Shell of medium size or a little larger, wider than long, the greatest width near the mid-length of the shell, subelliptical in outline, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete but somewhat crushed example are: length of pedicle valve 28 mm., length of brachial valve 24.5 mm., greatest width 30.6 mm., length of hinge-line 23 mm., thickness ±10 mm., height of cardinal area 3.5 mm. The dimensions of a nearly perfect brachial valve are: length 27 mm., greatest width 39.5 mm., length of hinge-line 27 mm., convexity 6 mm.

Pedicle valve convex, more or less distorted, depressed convex in the umbonal region with an irregular contour towards the lateral and anterior margins; mesial sinus obsolete; beak small, only slightly extended beyond the cardinal margin; cardinal area flat, of moderate height, sloping posteriorly from the hinge-line at an angle of 40 degrees or more, the delthyrium about as wide as high, covered by a convex deltidium. Internal characters not observed.

Brachial valve much more regularly convex than the pedicle, the greatest convexity near or posterior to the middle, the surface more or less compressed towards the cardinal extremities, the umbonal region not protuberant beyond the cardinal margin; mesial portion of the valve not differentiated. Surface of both valves marked by radiating costæ but those of the two valves somewhat different in character. The costæ of the pedicle valve are very slender and angular, separated by broad, flat, intercostal furrows, from one to three costæ occupy the space of one millimeter, the new ones being added by intercalation at intervals at the middle of the intercostal furrows; the costæ are crossed by exceedingly fine, somewhat wavy, concentric markings which are more conspicuous across the flat intercostal furrows; the valve also marked by strong, irregular, wrinkle-like, concentric markings. On the brachial valve the radiating costæ appear somewhat coarser because the intercostal furrows more nearly equal the costæ in width, although essentially the same number

occupy the space of one millimeter, these costæ increase by both bifurcation and intercalation and are crossed by concentric markings similar to those of the opposite valve but considerably fainter.

Remarks.—This species most resembles the specimens of *S. ruginosa* from the Salem and St. Louis limestone, both forms being characterized by the short hinge-line and by the strong, irregular, concentric wrinkles of the pedicle valve, but the brachial valve is much more regular in contour in this species than in the *S. ruginosa.* The species under discussion may be easily distinguished from *S. ruginosa* by the slender costæ of the pedicle valve with the broad intercostal furrows and by the character of the fine concentric markings, also by the difference in character of the radiating costæ of the two valves.

Horizon.—Chouteau limestone.

Streptorhynchus minutum (Cumings)
Plate VI, Figs. 16-21

1856. *Orthis umbraculum* Hall, Trans. Albany Inst., vol. 4, p. 12.
1883. *Streptorhynchus* (*Orthis*) *Umbraculum* Hall, 12th Rep. Geol. Surv. Ind., p. 325.
1901. *Orthothetes minutus* Cumings, Am. Geol., vol. 27, p. 147, pl. 15, figs. 1-16.
1906. *Orthothetes minutus* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1297, pl. 18, figs. 1-16. (Not pl. 20, fig. 7).

Description.—Shell very small, more or less distorted, wider than long, subelliptical to subquadrate in outline, the hinge-line a little shorter than the greatest width, the cardinal extremities angular. The dimensions of a small, complete specimen are: length of pedicle valve 2.1 mm., length of brachial valve 2 mm., greatest width 3.1 mm., length of hinge-line 2.9 mm., height of cardinal area .9 mm. The dimensions of a larger pedicle valve are: length 5.8 mm., greatest width 8.5 mm., length of hinge-line 7 mm., height of cardinal area 1.8 mm.

Pedicle valve usually convex in young examples, becoming concave towards the front margin with the continued growth of the shell, the surface most prominent at the apex of the valve, from which point it slopes in nearly straight, gently concave or gently convex lines anteriorly and laterally, always becoming concave towards the front in adult specimens; mesial sinus obsolete; beak obtusely pointed, usually nearly erect, sometimes a little recurved or slightly incurved; cardinal area of moderate height, usually nearly flat but sometimes a little concave or convex, the lateral margins usually sharply defined, sometimes rounding into the lateral slopes of the valve; the delthyrium triangular, about as wide as high, covered by a convex deltidium. Internally the cardinal teeth are widely divergent, the dental plates are restricted to slight ridge-like thickenings of the inner surface of the cardinal area on each side of the delthyrium, the muscular scars are ill-defined and inconspicuous.

Brachial valve convex, most prominent in the umbonal region near the hinge-line, the surface more or less compressed towards the cardinal extremities, the mesial portion of the valve sometimes slightly flattened or a little depressed; the beak inconspicuous, very slightly or not at all produced beyond the hinge-margin. Internally there is a broad and rather low cardinal process which is flanked on either side by a widely diverging socket-plate, from the outer surface of which the dental sockets are excavated.

Surface of both valves marked by fine, subangular, radiating costæ, from three to four in the space of 1 mm., which increase by intercalation and by bifurcation, crossing the costæ are exceedingly fine concentric markings which sometimes produce crenulations along the summits of the costæ. Stronger, concentric lines of growth are also frequently present.

Remarks.—This little shell is one of those which exhibits a distinct tendency towards an irregular growth of the shell. As it occurs in its typical form the specimens have some of the characteristics of immature shells, as if they might be the young of a larger form. Beede has identified as the same species certain much larger shells from the fauna of the Salem limestone, some of which attain a width of 50 mm. or more. These larger examples are evidently identical, specifically, with the shell described by Hall and Clarke as *Derbya ruginosa,* and if these minute examples are really the young of the larger ones, the name *S. minutum* will have to give way to Hall and Clarke's prior name. However, it does not seem to have been demonstrated as yet that the smaller forms are the young of the larger, for they do not commonly occur in actual association, and for the time being both names will be retained. The largest observed examples which are certainly referable to this species do not exceed 5 or 6 mm. in length.

Horizon.—Salem limestone.

Streptorhynchus ruginosum (Hall and Clarke)

Plate V, Figs. 1-19

1892. *Derbya ruginosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, p. 346, pl. 11A, figs. 25-27.
1897. *Derbya ruginosa* Hall, 14th Ann. Rep. N. Y. State Geol., p. 345, pl. 5, figs. 12-14.
1897. *Streptorhynchus williamsi* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 255, pl. 18, figs. 1-3.
1906. *Orthothetes minutus* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1297, pl. 20, fig. 7, (not pl. 18, figs. 1-16).

Description.—Shell of medium size or larger, transversely subelliptical in outline, the thickness sometimes nearly equaling the length, both valves unsymmetrically distorted and marked by strong, irregular, concentric

wrinkles; the hinge-line shorter than the greatest width of the shell, the cardinal extremities obtusely angular, the greatest width near the mid-length of the shell. The dimensions of the holotype are: length of pedicle valve 36 mm., length of brachial valve 33.8 mm., greatest width 45 mm., thickness 31.2 mm., length of hinge-line 32.5 mm., height of cardinal area ±8 mm.

Pedicle valve moderately deep, the surface flattened in the umbonal region, somewhat compressed towards the cardinal extremities, irregularly depressed or concave towards the lateral and anterior margins; mesial sinus obsolete; beak not prominent, probably but little or not at all elevated above the umbonal surface; cardinal area of moderate height, sloping a little posteriorly from the cardinal line to the apex, its lateral margins sloping in nearly straight lines from the beak to the cardinal extremities, sharply defined in the perfect shell; the delthyrium triangular, higher than wide. Internally the flabellate muscular scar reaches anteriorly to near the middle of the valve, a median septum is wanting and the dental plates are reduced to low ridges at the sides of the delthyrium.

Brachial valve strongly convex, much deeper than the pedicle, its greatest convexity a little posterior to the middle, moderately compressed towards the cardinal extremities, the umbo somewhat protuberant beyond the cardinal line; the beak incurved; mesial sinus obsolete. Internally the cardinal process is apparently of moderate size and fills the lower part of the delthyrium of the opposite valve, and the muscular scars occupy a subovate region a little less than one-third the length of the valve.

Surface of both valves marked by fine radiating costæ, from three to four of which occupy the space of one millimeter at the front of the type specimen, upon the partially exfoliated portions the positions of the costæ are indicated by lines of papillæ. The presence or absence of fine concentric markings is not indicated upon the type specimen, but both valves are marked by strong and irregular, wrinkle-like concentric markings which give to the entire shell a much distorted and irregular appearance.

Remarks.—This species was established by Hall and Clarke upon a single internal cast from a chert formation, to which some fragments of the shell substance adhere, and it is from this specimen that the above description has been chiefly made. It was originally described as a species of *Derbya*, although the presence of a median septum in the pedicle valve is not clearly shown as might be expected in such an internal cast. At one point, near the center of the flabellate muscular scar a slight median ridge is suggested, but nothing which can be compared with the strong median septum of other species which have been referred to the genus *Derbya*. The type specimen is said to have come from the "Keokuk limestone, New Providence, Indiana," but the lithologic character of the

specimen is not similar to the strongly ferruginous casts of shells which commonly come from that locality, and the specimen has rather the lithologic character of some of the St. Louis limestone cherts. Furthermore, in the collections examined, the species has been detected most commonly in the typical St. Louis limestone. These St. Louis limestone specimens agree well with the holotype of the species in the general form of the shell, in the size of the costæ, and in the extraordinary irregularity or distortion of the shell, but in no two examples are the irregularities of the shell form alike. In some specimens the umbonal region is much flattened, as in the type, while in others it is elevated and terminated by a pointed and more or less distorted beak. The convexity of the brachial valve is also a variable feature. An occasional example is found having a minimum amount of irregularity of shell growth. On grinding down the beak of several limestone examples, no median septum has been detected, which confirms the observation made upon the type specimen. The most important specific characters of the shell seems to be its irregularity of growth, although the proportional length of the hinge-line is rather constant, as well as the general outline of the shell.

Horizon.—Salem limestone, St. Louis limestone and Batesville sandstone.

Streptorhynchus ulrichi Hall and Clarke

Plate II, Figs. 17-18

1892. *Streptorhynchus Ulrichi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, p. 351, pl. 11B, fig. 15.
1897. *Streptorhynchus Ulrichi* Hall, 14th Ann. Rep. N. Y. State Geol., p. 350, pl. 6, fig. 3.

Description.—Shell below medium size, longer than wide, growing unsymmetrically and distorted, marked by strong, irregular, concentric lines of growth; the hinge-line shorter than the greatest width of the shell, the cardinal extremities angular, the greatest width anterior to the middle of the shell. The dimensions of the holotype, a pedicle valve, are: length from front margin to beak 22 mm., length from front margin to hinge-line 15 mm., greatest width 20 mm., length of hinge-line 16 mm., depth 6 mm.

Pedicle valve subtrihedral in general form, the surface somewhat flattened medially from the beak towards the front, but without a distinct sinus, sloping rather abruptly towards the postero-lateral margins and sometimes a little compressed near the cardinal extremities, becoming depressed towards the anterior margin in the holotype; beak prominent, distorted and produced posteriorly far beyond the hinge-line; cardinal area high, concave and somewhat distorted, the lateral margins sharply defined; delthyrium higher than wide, closed by a convex deltidium. Internally the hinge-teeth are supported by dental lamellæ which are pro-

duced anteriorly as low ridges along the posterior half of the muscular scar; no median septum; muscular scar ovate, extended anteriorly to beyond the mid-length of the valve; the anterior margin crenulate internally. Surface marked by numerous fine, but rather sharp, radiating costæ which increase by implantation, anteriorly the costæ are subequal, but towards the beak there is a series of stronger ones with from one to three finer ones between. The costæ are crossed by strong, irregular, concentric lines of growth, varying in strength in different parts of the valve.

Brachial valve not known.

Remarks.—This species is known only from a single specimen, the holotype, which is a silicified pedicle valve wholly free from matrix, both externally and internally, the valve is a little incomplete on the margin and has lost the terminal portion of the beak. From a single example, in this group of shells, the really essential specific characters can hardly be pointed out, and the above description is therefore the description of an individual rather than of the species. The characters most likely to be constant and of specific value are the relative proportions of length and breadth and the length of the hinge-line. Other examples, when found, will doubtless vary in the details of outline and in the surface markings, especially in the concentric markings of the shell.

Horizon.—Chester group.

Genus *ORTHOTETES* Fischer de Waldheim

Description.—Shell subplano-convex to biconvex, either regular or more or less distorted in manner of growth. The pedicle valve flat or convex, the cardinal area rather high and sloping posteriorly from the hinge-line, divided into a primary and secondary area as in *Schuchertella* and other allied genera, the delthyrium closed to the apex by the deltidium. Internally the dental lamellæ are produced anteriorly towards the inner floor of the valve and are joined to a median septum which sometimes reaches nearly half the length of the valve. Towards the apex of the beak is a small, triangular, pyramidal cavity or chamber formed by the two dental lamellæ internally and the inner surface of the deltidium externally. The brachial valve convex, with a very narrow cardinal area or with the cardinal area wanting.

Remarks.—The septate shells here included in the genus *Orthotetes* were referred to *Derbya* first by Waagen[1] and later by Hall and Clarke,[2] the name *Orthothetes* being used by these authors for a large group of non-septate shells. It has been shown by Girty,[3] however, that the original

1 Mem. Geol. Surv. India, ser. 13, vol. 1, p. 591 (1887).
2 Pal. N. Y., vol. 8, pt. 1, p. 261 (1892).
3 The Guadalupian Fauna, pp. 186-199 (1908).

specimens of *Orthotetes* described and illustrated by Fischer de Waldheim were examples of a septate shell essentially identical as to generic characters with Waagen's and Hall and Clarke's interpretation of *Derbya*. For the accommodation of the nonseptate shells called *Orthotetes* by these authors, Girty has proposed the name *Schuchertella*, which genus has already been discussed in this report. Among the septate shells two rather distinct types are recognized, in one of which, the true *Orthotetes*, the septa are joined to form a small triangularly pyramidal cavity in the rostral portion of the pedicle valve, while in the other group, for which the name *Derbya* is retained, no such rostral cavity is present. In the Mississippian faunas here considered only two species of these septate shells are recognized, in both of which the rostral cavity is commonly present, although it is often small and sometimes the union of the dental lamellæ with the septum is more or less incomplete.

Orthotetes keokuk (Hall)

Plate VII, Figs. 1-4

1849. *Orthis crenistria* Yandall and Shumard, Cont. to Geol. Ky., pp. 19, 21.
1858. *Orthis keokuk* Hall, Geol. Iowa, vol. 1, pt. 2, p. 640, pl. 19, figs. 5a-b.
1883. *Streptorhynchus keokuk* Hall, Rep. N. Y. State Geol. for 1882, pl. (11) 41, figs. 1-3.
1890. *Orthis keokuk* Gordon, Am. Geol., vol. 5, p. 261, pl. 1, fig. 7.
1892. *Derbya Keokuk* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 11, figs. 1-3.
1894. *Orthis keokuk* Keyes, Mo. Geol. Surv., vol. 5, p. 63.
1899. *Derbya keokuk* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 524.

Description.—Shell large, transversely subelliptical in outline, the greatest width near the mid-length of the shell, the hinge-line shorter than the greatest width, the cardinal extremities rounded or obtusely angular. The dimensions of a nearly complete but somewhat undersized specimen are: length of pedicle valve 64 mm., length of brachial valve 60 mm., greatest width +80 mm., length of hinge-line ±65 mm., height of cardinal area 8.7 mm., thickness of shell 25.6 mm.

Pedicle valve nearly flat, usually slightly concave in the central portion and a little elevated in the umbonal region towards the beak; mesial sinus obsolete; cardinal area flat, of moderate height, sloping posteriorly from the hinge-line to the apex at an angle of about 128 degrees to the plane of the valve, the lateral margins sharply defined and angular; the delthyrium about as wide or a little wider than high, completely closed by a convex deltidium. Internally a strong median septum extends from the beak anteriorly for about one-third the length of the valve; the teeth are supported by short, non-septate dental plates which are scarcely more than thickened ridges upon the inner surface of the shell, one on each side

of the delthyrium, the dental plates usually join the median septum near the beak to form a shallow, triangular chamber in the apex of the valve; the muscular impression is large and flabellate, triangularly subovate in outline, not deeply impressed, and reaching nearly or quite to the middle of the valve.

Brachial valve strongly convex, the greatest convexity posterior to the middle, the surface curving more abruptly to the cardinal margin and less abruptly to the lateral and anterior margins, distinctly compressed towards the cardinal extremities, the umbo projecting slightly posteriorly beyond the hinge-line; median sinus obsolete, although the median portion of the valve is frequently if not always slightly flattened. Internally the cardinal process is strong, extending conspicuously beyond the cardinal margin, it is slightly bifid at the extremity and is produced anteriorly as a distinct, flattened, ridge-like thickening upon the inner surface of the valve, which at first contracts in width from the base of the cardinal process and then expands anteriorly as it is gradually merged with the general inner surface within the umbonal region of the valve; at the base of the cardinal process the hinge sockets are excavated in the sides of that process, the socket or crural plates being insignificant in their development; muscular scars ill-defined, often scarcely distinguishable.

Surface of both valves marked by fine, subangular, radiating costæ which are somewhat irregular in size and increase by bifurcation and intercalation, from 1 to 3 occupying the space of one millimeter. When the surface is uninjured the costæ are crossed by exceedingly fine, concentric striæ, and by occasional, distinct, concentric, wrinkle-like lines of growth. Upon the internal surface of the shell, as shown in internal casts, concentric markings nearly equaling the radiating costæ in size, but somewhat more weakly developed, are commonly noticeable, which give to the surface a distinctly reticulate appearance.

Remarks.—It has been shown by Girty[1] that the typical species of the genus *Orthotetes* Fischer de Waldheim, possesses a median septum in the pedicle valve, which is the essential character of the genus *Derbya* as defined by Waagen, a condition which necessitates the abandonment of the name *Derbya* and the substitution of a new generic name for the shells to which Hall and Clarke have applied the name *Orthotetes*. There are recognized among the septate shells of Waagen's genus *Derbya,* two rather distinct groups of species, in one of which the septate dental plates join with the median septum and, with the delthyrium, enclose a triangular chamber in the apical portion of the pedicle valve, while in the second group of species no such triangular chamber is present. It happens that the genotype of *Orthotetes* is a member of the first or camerate division of the genus, while that of *Derbya* is one of the simply septate forms, so

[1] U. S. Geol. Survey, Prof. Paper, No. 58, pp. 186-199 (1908).

that if it be considered advisable to retain the two groups as of generic value the name *Orthotetes* would be applicable to one and *Derbya* to the other. This procedure seems to be unwarranted, however, for the reason that the species under consideration, *O. keokuk*, is essentially intermediate in character between the two types. In it, the dental plates cannot be said to be septate, but near the apex of the valve they usually do join the median septum in such a manner as to inclose a short triangular chamber, but not a deep one extending from the apex to or nearly to the hinge-line, as in the case of the more typical representatives of the camerate division. In some examples of *O. keokuk* the triangular chamber may be scarcely distinguishable at all, and in one specimen observed the dental plate is joined with the median septum on one side but not on the other.

This species is the largest representative of this type of shell in our Mississippian faunas, and sometimes attains a width of 100 millimeters.

Horizon.—Keokuk limestone.

Orthotetes kaskaskiensis (McChesney)

Plate VI, Figs. 1-14, 15?

1860. *Orthis kaskaskiensis* McChesney, Desc. New Pal. Foss., p. 31.
1892. *Derbya kaskaskiensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 11B, fig. 6.

Description.—Shell above medium size, subelliptical or subcircular in outline, often somewhat distorted, broader than long, the greatest width near the mid-length of the shell, the hinge-line shorter than the greatest width, the cardinal extremities rounded or obtusely angular. The dimensions of two nearly perfect specimens are: length of pedicle valve 41 mm. and 28.3 mm., length of brachial valve 37.7 mm. and 25.2 mm., greatest width 49.5 mm. and 34.8 mm., length of hinge-line 35.5 mm. and 28.5 mm., height of cardinal area 9 mm. and 5.6 mm., thickness from deepest part of brachial valve to apex of pedicle valve 19.5 mm. and 14 mm.

Pedicle valve nearly flat or somewhat concave except in the umbonal region where the beak is frequently rather abruptly elevated, sharply pointed and more or less distorted; mesial sinus obsolete; cardinal area nearly flat, sometimes a little concave or convex towards the apex, sloping posteriorly from the hinge-line at an angle of from 100 to 140 degrees, most commonly about 120 degrees, the lateral margins well defined and sharply angular, sloping from the apex of the beak to the cardinal extremities in nearly a straight line or with a slight concavity near the beak and a slight convexity near the cardinal extremities; delthyrium much higher than wide, closed by a rather strongly convex deltidium which is usually longitudinally flattened or slightly sinuate. Internally a strong median septum originates at the beak and extends anteriorly, the dental plates are short, nonseptate, being scarcely more than thick-

ened ridges on the interior of the shell, one at each margin of the delthyrium, near the apex of the beak the dental plates are sometimes slightly extended anteriorly and join with the median septum to form a shallow, triangular chamber.

Brachial valve convex throughout except towards the cardinal extremities, which are compressed, the greatest convexity posterior to the middle, the surface curving more abruptly to the cardinal margins, the umbonal region not protuberant beyond the cardinal margin; mesial portion of the valve not differentiated. Internal characters not observed.

Surface of both valves marked by abruptly elevated, radiating costæ which commonly alternate in size, and which increase by bifurcation and implantation. From two to three costæ occupy the space of 1 mm., the intercostal spaces usually being a little broader than the costæ. The costæ are crossed by more or less wrinkle-like, concentric lines of growth which are variously distributed, usually being somewhat more crowded towards the margin of mature shells, and by very fine raised concentric lines which are best developed in the intercostal spaces and which give to the surface, with the costæ, a finely reticulate appearance when they are best developed.

Remarks—This species differs from *O. keokuk* in its smaller size, its less protuberant umbonal region in the brachial valve, and usually in the more abruptly elevated and more acute beak of the pedicle valve. The relation of the dental plates to the median septum is similar to that in *O. keokuk*, these species being somewhat intermediate in condition between the camerate and septate divisions of the genus. Hall and Clarke illustrate an internal view of an example which shows a shallow triangular chamber in the beak of the pedicle valve, but other specimens which have been examined indicate that no junction of the dental plates with the septum exists, and consequently no triangular chamber.

Horizon.—Ste. Genevieve limestone and Chester group.

Family PRODUCTIDÆ

Genus *CHONETES* Fischer de Waldheim

Description.—Shell usually small, concavo-convex, subsemicircular in outline, broader than long, the greatest width along the hinge-line. Pedicle valve convex, usually flattened towards the cardinal extremities, with a narrow cardinal area; the delthyrium closed to the apex by the deltidium; the lateral margins of the area sharply defined, bearing a single row of hollow, vertical or divergent spines which increase in length towards the cardinal extremities; internally the muscular scars are usually faint, the surface outside the scars is strongly papillose, the papillæ appearing in internal casts as pits. Brachial valve concave, with a cardinal area much narrower than that of the opposite valve, and without marginal spines;

internal surface papillose as in the opposite valve. External surface of both valves marked by usually fine, radiating costæ, sometimes concentrically marked also, rarely nearly smooth.

Remarks.—This easily recognized genus is represented by numerous species and an abundance of individuals in the lower Mississippian faunas, but after the close of the Osage epoch it becomes exceedingly rare. The spines of the cardinal margin, which are so characteristic of the genus are rarely well preserved, but their bases commonly can be detected upon most fairly preserved specimens.

CHONETES MULTICOSTA Winchell

Plate VIII, Figs. 8-16

1863. *Chonetes multicosta* Winchell, Proc. Acad. Nat. Sci. Phil., p. 5.
1869. *Chonetes multicosta* Winchell, Safford's Geol. Tenn., p. 443.
1870. *Chonetes multicosta* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 250.
1909. *Chonetes illinoisensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 297, pl. 12, fig. 11.

Description.—Shell concavo-convex, length two-thirds, or a little less, of the width, the greatest width usually at the hinge-line but in some specimens the hinge-line is a little shorter than the greatest width, the cardinal extremities usually nearly rectangular, the lateral margins straight or slightly convex posteriorly, becoming regularly convex anteriorly and passing with unbroken curvature into the anterior margin which becomes gently convex or nearly straight in its median portion. The dimensions of Winchell's type specimen, a pedicle valve, are: length 13 mm., width 20.5 mm., convexity 3.5 mm.

Pedicle valve depressed-convex, the greatest convexity posterior to the middle, compressed towards the cardinal extremities, the surface flattened along the mesial region and usually slightly depressed in a rather broad, shallow, ill-defined mesial sinus in the anterior two-thirds of the shell; beak small, very slightly produced beyond the cardinal margin; cardinal area narrow, slightly concave, lying at an angle of about 140 degrees to the plane of the valve, its lateral margins sharply defined and bearing about five oblique spines on each side of the beak; the delthyrium broadly triangular, much wider than high. The inner surface of the valve finely papillose beyond the middle, the papillæ appearing as small pits upon the surface of internal casts of the valve.

Brachial valve only moderately concave, somewhat flattened towards the cardinal extremities. The cardinal area not well shown on any of the examples examined, but it is probably small. The internal characters not observed.

Surface of both valves marked throughout by fine, usually regular, radiating costæ, which increase by bifurcation on the pedicle valve and

by intercalation on the brachial valve, from 200 to 235 are present at the distal margin of full grown shells, from 17 to 20 occupying the space of three millimeters; near the beak and towards the cardinal extremities they become somewhat finer than in the middle part of the front of the shell.

Remarks.—The specimens indicated as the types of this species in the University of Michigan collection are eight in number, their horizon and locality being marked "Chemung Group, Burlington, Ia." The so-called Chemung Group at Burlington, of Winchell's time, is now included in the Kinderhook, and to one familiar with the Burlington section the several specimens may be recognized from their lithologic characters as having come from more than one horizon in the Kinderhook, and perhaps even from the base of the Burlington limestone. At least four of the specimens are clearly from bed No. 7, the topmost bed of the Kinderhook at Burlington, two examples, which may be specifically distinct, are from the Chonopectus sandstone; one is from a white, granular chert which may be from the Kinderhook oolite bed, but is more probably from the Burlington limestone; and the last specimen is from the brownish, crystalline limestone which is so characteristic of the lower Burlington. The measurements given by Winchell in his original definition of the species, agree with those of the last specimen mentioned above from the Lower Burlington limestone, and as this is in many respects the most perfect individual of the lot it is believed to be the one from which the greater part of the original definition was written.

The species has been commonly confused with *C. illinoisensis*, but a careful study of the original specimens seems to establish the species as a good one. It grows to a larger size than *C. illinoisensis* and has more angular cardinal extremities, the greater width of the shell usually being along the hinge-line, while in *C. illinoisensis* the hinge-line is distinctly shorter than the greatest width and the cardinal extremities are rounded. The radiating costæ are also often somewhat finer than in *C. illinoisensis*, although this distinction is not always to be depended upon, since the more finely marked examples of *C. illinoisensis* are essentially identical in this character with the more coarsely marked specimens of *C. multicosta;* on the average, however, the costæ of *multicosta* are slightly finer than those of *illinoisensis*. In no specimen examined have the cardinal spines been well preserved, and even the spine bases are commonly very obscure, but there are clearly more than two or three, as indicated by Winchell, and there is apparently no basis for the statement of that author that they extend at nearly right angles to the hinge-line.

Horizon.—Upper Kinderhook and Burlington limestone.

Chonetes illinoisensis Worthen

Plate VIII, Figs. 63-70

1858. *Chonetes logani* Hall, Geol. Iowa, vol. 1, pt. 2, p. 598, pl. 12, figs. 1a-e, 2. (Not *C. logani* N. & P., 1855.)
1860. *Chonetes Illinoicusis* Worthen, Trans. St. Louis Acad. Sci., vol. 1, p. 571.
1863. *Chonetes Illinoiensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 5.
1865. *Chonetes Illinoisensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 116.
1868. *Chonetes Illinoisensis* Meek and Worthen, Geol. Surv. Ill., vol. 3, p. 505, pl. 15, figs. 8a-b.
1870. *Chonetes Illinoisensis* Winchell, Proc. Amer. Phil. Soc., vol. 11, p. 251.
1888. *Chonetes illinoiscusis* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 35, pl. 3, fig. 21.
1890. *Chonetes illinoisensis* Herrick, Bull. Geol. Soc. Amer., vol. 2, p. 48, pl. 1, fig. 16.
1894. *Chonetes illinoisensis* Keyes, Mo. Geol. Survey, vol. 5, p. 53.
1903. *Chonetes illinoisensis* Girty, U. S. Geol. Survey, Prof. Paper No. 16, p. 279.

Description.—Shell concavo-convex, the length about two-thirds the width, the hinge-line usually a little shorter than the maximum width, the hinge extremities a little rounded or nearly rectangular, lateral margins slightly convex or nearly straight, more strongly curved anteriorly and passing with a regular curvature into the anterior margin, which becomes nearly straight for a short distance in the middle portion. The dimensions of a specimen of about average size are: length 11.9 mm., width 16.3 mm., convexity 3.6 mm.

Pedicle valve depressed convex, the greatest convexity posterior to the middle, compressed towards the cardinal extremities, flattened along the mesial region and sometimes depressed in a shallow, ill-defined mesial sinus; the beak small, scarcely extended beyond the cardinal margin; cardinal area narrow, slightly concave, lying at an angle of about 145 degrees to the plane of the valve, its lateral margins sharply defined and bearing five or six oblique spines upon each side; the delthyrium broadly triangular, about twice as wide as high, the deltidium small, confined to the apex and margins of the delthyrium.

Brachial valve only slightly concave, a little flattened towards the cardinal margins; the cardinal area not well shown on any of the authentic specimens, but it is probably small. Internally the cardinal process is of moderate size, and from its anterior side a pair of ridges of variable strength diverge widely, becoming nearly parallel with the cardinal margin and extending nearly half way to the cardinal extremities; a second pair of ridges originate in front of the cardinal process, border the basal portion of the muscular scar, diverging with an angle of about 50 degrees,

between them a median ridge develops and continues anteriorly sometimes reaching the middle of the valve; towards the anterior border and extending to the lateral borders, the inner surface of the valve is papillose, the papillæ being arranged more or less regularly in radiating lines, and the inner border of the valve is costate, the costæ corresponding with those of the external surface.

The surface of both valves is marked throughout by fine, nearly regular, radiating costæ, which increase by bifurcation on the pedicle valve and by intercalation upon the brachial valve. The total number of costæ varies from 175 to 225, according to the size of the individual, but the size of the costæ is nearly constant, about six occupying the space of one millimeter, except near the beak, where they are somewhat finer.

Remarks.—The typical horizon for this species is the Burlington limestone, where it sometimes occurs in great numbers. Ordinarily the average size of the species is about 15 mm. or a little more in width.

In Worthen's original description of the species the number of costæ are said to be 100 to 120 or more, but this number is understated, as has been determined from the examination of authentic examples from the typical locality. In Meek and Worthen's description of the species 12 to 14 costæ are said to be present in .10 inch, which would be nearly the number observed on specimens studied by the writer, 6 costæ in 1 mm. would be equivalent to 15 in .10 inch. Winchell's *C. multicosta* is a closely allied species, but grows to a larger size; it also has a longer hinge-line and more angular cardinal extremities than *C. illinoisensis*, and usually has somewhat finer costæ. *C. shumardiana* DeKoninck, with which *C. illinoisensis* has sometimes been confused, is an entirely different species, and a comparison of the two forms is made under the description of that species.

Horizon.—Burlington limestone, Keokuk limestone.

Chonetes missouriensis n. sp.

Plate VIII, Fig. 20

Description.—Shell transversely subelliptical in outline, the hinge-line a little shorter than the greatest width of the shell, the cardinal extremities obtusely angular or a little rounded. The lateral margins gently convex posteriorly, curving more rapidly towards the front and passing without interruption into the anterior margin which is gently convex in the middle. The dimensions of the holotype are: length 16.7 mm., width 26 mm., convexity 5 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the beak and gently to the cardinal margin, becoming compressed towards the cardinal extremities; the median portion of the valve flattened or slightly depressed in a broad, shallow, ill-defined median

sinus; the umbo a little prominent and projecting slightly beyond the cardinal margin; the beak small and incurved; the cardinal margin sharply defined and bearing about four spines on each side of the beak; cardinal area not observed.

Brachial valve only moderately concave, flattened towards the cardinal extremities, the greatest concavity posterior to the middle. Internally the cardinal process is small and is flanked by a pair of widely divergent ridges which become nearly parallel with the cardinal margin and reach about one-third the distance to the cardinal extremities, and in whose posterior side the dental sockets are excavated; in front of the socket ridges a well-defined median septal ridge reaches to about the middle of the valve, and also a pair of ridges, one on each side of the median ridge, which originate at the base of the median ridge, with a slight divergence, and curve towards the lateral margins, distally attaining a length of about two-thirds that of the median ridge.

Both valves marked by fine, rounded, radiating costæ, separated by narrower intercostal furrows, the costæ increase by division on the pedicle valve and by intercalation on the brachial valve, from 3 to 4 occupy the space if 1 millimeter, about 170 being present altogether upon the specimen whose dimensions have been given. Crossing the costæ are several irregularly distributed lines of growth of variable strength.

Remarks.—This species is most nearly allied to *C. illinoisensis* but it attains a larger size and has a much coarser costæ, there being only 3 or 4 in the space of 1 millimeter, while in *C. illinoisensis* there are 6 in the same space.

Horizon.—Pierson limestone of the Kinderhook.

Chonetes chesterensis n. sp.

Plate VIII, Figs. 31-34

Description.—Shell concavo-convex, the length about two-thirds the width, the greatest width along the hinge-line, the cardinal extremities angular; lateral margins nearly straight or slightly concave in front of the cardinal extremities, convexly curved anteriorly and passing with unbroken curvature into the anterior margin which becomes nearly straight in its central portion. The dimensions of two specimens are: length of pedicle valve 8.2 mm. and 8.7 mm., length of brachial valve 7.1 mm. and 7.8 mm., greatest width 12.6 mm. and 12.5 mm., convexity 2 mm. and 2.5 mm.

Pedicle valve depressed-convex, the greatest convexity near the middle, the surface curvature a little more abrupt to the anterior margin than towards the beak, compressed towards the cardinal extremities; beak small, scarcely produced beyond the cardinal margin; cardinal area low, nearly flat except towards the apex where it is slightly concave, lying

at an angle of about 130 degrees to the plane of the valve, its lateral margins sharply defined and bearing six oblique spines upon each side of the beak; delthyrium broadly triangular, the deltidium confined to the apex and the lateral margins. Internal characters not observed.

Brachial valve gently concave posteriorly, becoming more strongly curved towards the anterior and lateral margins; cardinal area about one-half the height of that of the opposite valve, with which its surface makes a very broad angle, being nearly 180 degrees. The cardinal process filling the greater portion of the delthyrium of the other valve, the remaining internal characters not observed.

Surface of both valves marked by fine, regular, radiating costæ which increase by bifurcation and interealation, from 100 to 120, are present about the margin of an average specimen, about five or sometimes six occupying the space of one millimeter, except towards the cardinal extremities where they become finer and more or less obscure, they are also somewhat finer towards the beaks of the valves.

Remarks.—This species has its nearest allies in *C. illinoisensis* and *C. multicosta.* It differs from both these species in its smaller size, and from *C. illinoisensis* it differs in its proportionately more elongate hinge-line, the greatest width of the shell being at the hinge-line. The proportional length of the hinge-line is similar to that of *C. multicosta* but besides being a much smaller species it possesses somewhat coarser costæ. The species is the only one as yet observed in the Chester faunas, where it is one of the rarer forms.

Horizon.—Chester group, Paint Creek formation.

Chonetes logani Norwood and Pratten

Plate VIII, Figs. 43-46

1855. *Chonetes Logani* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil. (2), vol. 3, p. 30, pl. 2, figs. 12a-c.
1865. *Chonetes Logani* Winchell, Proc. Acad. Nat. Sci. Phil., p. 116.
1867. *Chonetes logani* Hall, Pal. N. Y., vol. 4, pl. 22, figs. 23, 26-27.
1888. *Chonetes logani* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 35, pl. 7, fig. 22, pl. 3, fig. 12.
1888. *Chonetes logani* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 35, pl. 7, fig. 22; pl. 3, fig. 12.
1892. *Chonetes Logani* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 16, fig. 25.
1894. *Chonetes logani* Keyes, Mo. Geol. Surv., vol. 5, p. 53.
1901. *Chonetes logani* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 182, pl. 16, figs. 10-11.
1909. *Chonetes logani* Weller, Bull. Geol. Soc. Am., vol. 20, p. 299, pl. 12, figs. 12-13.

Description.—Shell strongly convex, subsemielliptical in outline, the greatest width along the hinge-line, the cardinal extremities acutely an-

gular or sometimes approaching rectangular, the auricular portion small and not sharply differentiated from the body of the shell, the lateral margins nearly straight or slightly concave posteriorly, convex anteriorly and passing without break into the regularly rounded anterior margin, the length usually a little less than two-thirds the width. The dimensions of three specimens are: length 6.3 mm., 6.8 mm., 10.5 mm.; width 8.9 mm., 9.5 mm., 13.5 mm.; convexity 2.6 mm., 3.5 mm., 5.8 mm.

Pedicle valve most convex near or a little posterior to the middle, the surface curving abruptly to the beak and a little more gently to the anterior margin, compressed towards the cardinal extremities but with the auriculations small, not sharply differentiated, and convex from the cardinal margin posteriorly; mesial sinus obsolete; the beak small, produced slightly beyond the cardinal margin, the umbonal surface smooth for a short distance from the beak; the cardinal area narrow, slightly concave, extending posteriorly in nearly the plane of the valve, the delthyrium small, the cardinal margin sharply defined, bearing two or three spines on each side of the beak, all of which are directed obliquely outward. Internally the muscular scars are rather strongly defined, and are divided along the median line of the valve by a median septum which varies in strength in different individuals from a slightly raised line to a strongly raised, narrow ridge; beyond the limits of the muscular scars the surface is papillose throughout.

Brachial valve deeply concave, the greatest concavity near the middle, becoming flatter and only gently concave in the auricular regions towards the cardinal extremities; the cardinal area narrower than that of the opposite valve and meeting it in an obtuse angle; the costæ do not extend to the beak but leave a small, smooth area at the apex of the valve in the middle of which, adjacent to the cardinal margin, a small, node-like prominence is sometimes present.

Surface of both valves marked by rather broad, depressed, rounded costæ much broader than the intervening furrows, about three of which occupy the space of one millimeter, on the pedicle valve they increase by division and on the brachial valve by implantation; crossing the costæ are exceedingly fine, raised concentric lines, 10 or more in the space of one millimeter, which are obsolete in the furrows between the costæ, and give to the costæ a distinctly crenulate appearance; the costæ do not originate at the beak, but at a little distance to the front, and they become faint or sometimes obsolete towards the cardinal extremities.

Remarks.—This species is a common member of the fauna of the Kinderhook oolite bed at Burlington, Iowa, where it is associated with the less common *C. burlingtonensis*, from which it differs in its greater convexity, its greater proportional length, its broader and less numerous costæ, and the transverse crenulations of the costæ. In the transverse markings of

the costæ the species resembles *C. ornatus* of the Louisiana limestone, but the shell is more strongly convex with less well developed auriculations and with less elevated costæ.

Horizon.—Kinderhook.

Chonetes ornatus Shumard

Plate VIII, Figs. 21-29

1855. *Chonetes ornata* Shumard, Geol. Rep. Mo., p. 202, pl. C, figs. 1a-c.
1894. *Chonetes ornata* Keyes, Mo. Geol. Survey, vol. 5, p. 53, pl. 38, fig. 2.
1899. *Chonetes ornatus* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 527, pl. 68, figs. 4a-d.
1908. *Chonetes ornatus* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 75, pl. 17, figs. 20-23.

Description.—Shell subsemielliptical in outline, wider than long, the length a little more than two-thirds the width, the greatest width usually along the hinge-line, the cardinal extremities angular, the lateral margins a little sinuate or nearly straight in the posterior half, passing with a regular curvature into the anterior margin in front. The dimensions of two examples are: length 6.9 mm. and 7.5 mm., width 10 mm and 11.5 mm., convexity 2.7 mm. and 3 mm.

Pedicle valve moderately convex, the greatest convexity near or a little posterior to the middle, compressed towards the cardinal extremities with a rounded ill-defined sinus passing from each side of the beak obliquely to the lateral margins, the auriculations formed by these oblique sinuses are convex in an antero-posterior direction; mesial sinus obsolete or represented by a slight mesial flattening of the valve; beak small, compressed, scarcely extending beyond the cardinal margin; cardinal area narrow, nearly flat, extending posteriorly in nearly the plane of the valve; the delthyrium small, about as wide as high, about one-half of its area, the apical portion, covered by a convex deltidium with a sinuate cardinal margin; the cardinal margin sharply defined, sloping from each side of the beak to the cardinal extremities and bearing one, two, or three spines upon each side.

Brachial valve rather deeply concave in the middle, flattened and auriculate towards the cardinal extremities, the auriculations being concave in an anterior-posterior direction; cardinal area with a sharply defined margin, much narrower than that of the opposite valve, the areas of the two valves meeting in an obtuse angle; at the center, opposite the delthyrium of the opposite valve, a prominent, convex chilidium surrounds the posterior surface of the cardinal process.

Surface of each valve marked by from thirty to thirty-eight rounded costæ, none of which occupy the auricular portions, from two and one-half to three occupying the space of one millimeter; those of the pedicle valve increase by bifurcation and those of the brachial valve by implan-

tation. In addition to the costæ each valve is ornamented by exceedingly fine concentric markings, stronger on the pedicle than on the brachial valve, which are obsolete in the furrows between the costæ, and by stronger concentric lines of growth which sometimes become lamellose.

Remarks.—This species has sometimes been confused with the form here referred to *C. glenparkensis*, indeed Shumard, the author of the species, probably included in it specimens which are really *C. glenparkensis*, as he mentions a Chouteau limestone locality, Cooper County, Missouri, as one of his type localities. Among recent collections the species has been observed only in the fauna of the Louisiana limestone, all the Chouteau limestone examples with similar markings being *C. glenparkensis*. The species differs from *C. logani* in its somewhat larger size, its more conspicuous auriculations, its stronger and somewhat coarser costæ. It resembles *C. logani* in its fine concentric markings which are conspicuous upon the tops of the costæ and become obsolete in the intervening furrows.

Horizon.—Louisiana limestone.

CHONETES GLENPARKENSIS Weller

Plate VIII, Figs. 30, 47-49

1906. *Chonetes glenparkensis* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 441, pl. 6, fig. 7.

Description.—Shell subsemielliptical in outline, the length about two-thirds the width, the greatest width along the hinge-line, the cardinal extremities acutely angular and sometimes a little acuminate. Lateral margins nearly straight or slightly concave posteriorly, their directions converging anteriorly, towards the front they round into the regularly convex anterior margin without interruption. The dimensions of two specimens are: length 8 mm. and 7.5 mm., width ±12.5 mm. and ±12.4 mm., convexity 2.8 mm. and 3 mm.

Pedicle valve strongly convex, inflated in the central portion and conspicuously compressed towards the cardinal extremities, the auriculations convex from the cardinal margin anteriorly, the greatest convexity of the valve near the middle, the surface curving a little more abruptly to the beak than to the anterior margin; mesial sinus obsolete; the umbo rather prominent and a little protuberant beyond the cardinal margin; the beak small and incurved; cardinal margin sharply defined, with three or four spines on each side of the beak directed obliquely outward. Internally the muscular scars are only moderately developed, being divided along the median line of the shell by a slight ridge extending anteriorly from the beak; beyond the region occupied by the muscular impressions the surface is strongly papillose, the papillæ being arranged in more or less regular, radiating lines and being obsolete towards the cardinal extremities.

Brachial valve deeply concave, the greatest concavity near the middle, the concavity becoming shallow in the auricular portions of the valve towards the cardinal extremities; the cardinal area, the cardinal process and the internal characters of the valve not observed.

Surface of both valves marked by rather coarse, rounded, radiating costæ, separated by intercostal furrows about equal to the costæ in width, and increasing by division and intercalation; from two to three costæ occupy the space of one millimeter, about 35 being present altogether upon an average sized specimen, upon the auricular portions of the shell they become faint or entirely obsolete. Crossing the costæ are fine, raised, concentric markings which are strongly developed upon the tops of the costæ and are entirely obsolete in the intercostal furrows, giving to the costæ in well preserved specimens a strongly crenulate appearance.

Remarks.—This species was originally described from a single individual from the Glen Park limestone, which was evidently water-worn before it was fossilized. A comparison of this specimen with numerous individuals from the Chouteau limestone seems to establish the identity of the two forms. In the Glen Park specimen, a pedicle valve, the auricular portions of the shell have been eroded and the cardinal extremities seem to be rounded; but the size and convexity of the valve, the costæ, and the nature of the concentric markings are entirely similar in the Glen Park and the Chouteau limestone specimens. The only difference worthy of note is the slightly coarser and consequently less numerous costæ on the Glen Park specimen, although some individuals or some parts of individuals from the Chouteau limestone have fully as coarse costæ as does the Glen Park specimen. The description here given has been drawn up primarily from the Chouteau limestone specimens.

The Chouteau limestone specimens included in this species were originally included in the species *C. ornatus* by Shumard, and the original illustration of that species was perhaps taken from one of this species. The description of *C. ornatus*, however, seems to have been chiefly taken from the Louisiana limestone specimens, and the name is here restricted to the shells from that formation. *C. glenparkensis* differs from *C. ornatus* in the much greater convexity or inflation of the pedicle valve and the greater concavity of the brachial valve, and in the greater extension of the shell along its hinge-line and consequently in the more conspicuous auriculations of the shell. The ornamentation of the surface, especially the crenulated costæ, is similar in the two species, and this character was evidently considered as of specific rank by Shumard, but it is now known to be common to several species of the genus. The species is perhaps most closely allied to *C. logani*, and has sometimes been so identified, but it may be distinguished by its greater average size, although some examples of *C. logani* are fully as large as any example of *C. glenparkensis*,

by the greater extension of the hinge-line and more conspicuous auriculations of the shell, and by the somewhat coarser costæ separated by proportionally wider intercostal furrows.

Horizon.—Glen Park limestone and Chouteau limestone of the Kinderhook.

CHONETES SHUMARDANUS DeKoninck

Plate VIII, Figs. 1-7

1847. *Chonetes shumardiana* DeKoninck, Monog. du Gen. Prod. et Chon., p. 192, pl. 20, figs. 1a-d.
1855. *Chonetes Shumardiana* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., (2), vol. 3, p. 24.

Description.—Shell semielliptical in outline, the proportional length, breadth, and convexity variable, the greatest width along the hinge-line, the cardinal extremities usually nearly rectangular; the lateral margins nearly straight posteriorly, curving regularly into the anterior margin in front. The dimensions of three nearly perfect examples are: length 16 mm., 12.5 mm. and 11.5 mm., width 22 mm., 15 mm. and 17 mm., convexity 6 mm., 5.5 mm. and 4.2 mm.

Pedicle valve varying in its convexity, but never extreme in either direction, the greatest convexity near or a little back of the middle, compressed and auriculate towards the cardinal extremities but with the auriculations not sharply differentiated from the body of the shell; mesial sinus entirely obsolete; the beak small and inconspicuous, the umbo projecting a little beyond the cardinal margin; cardinal area nearly flat, slightly twisted towards the cardinal extremities, lying in nearly the plane of the valve; the delthyrium about as wide as high, closed towards its apex by a convex deltidium, its lower portion filled by the posterior portion of the cardinal process of the opposite valve; the cardinal margins sharply defined, bearing the bases of from 3 to 5 oblique spines. Internally the muscular scars are heart-shaped in outline and in the younger individuals reach nearly to the middle of the valve, becoming proportionally smaller with age, they are well developed and become rather deeply impressed in old shells, a thin median septum is present which extends from the beak nearly to the middle of the muscular scar, towards the cardinal extremities the valve is thickened internally, the thickened portion more or less sharply differentiating a central, subovate, deeply concave region from the more flattened, subtriangular regions towards the cardinal extremities; the inner surface of the valve, beyond the muscular scars, covered by papillæ which are scattered towards the central portion of the valve, becoming much more numerous and more prominent towards the lateral and anterior margins.

Brachial valve deeply concave in the central portion, with an indistinct sinus on each side extending from the center obliquely towards the car-

dinal extremities; cardinal area much narrower than that of the opposite valve and sloping anteriorly so as to form a very wide angle with it, each side a little twisted towards the cardinal extremities and sloping gently from the lateral extremities to the center so that the two sides are not in one plane; the quadri-partate posterior extremity of the cardinal process is distinctly visible at the center of the cardinal area and fills a portion of the delthyrium of the opposite valve. Internally the cardinal process is prominent and the muscular scars are large and well defined, the inner surface, including a portion of the surface of the muscular scars, is covered with papillæ which are arranged more or less definitely in radiating rows towards the lateral and anterior margins.

Surface of both valves marked by fine radiating costæ, variable in width, from 5 to 9 occupying the space of one millimeter, they increase by bifurcation upon the pedicle valve and by implantation on the brachial; they are crossed by much finer, raised, concentric markings which are obsolete in the furrows between the costæ, giving to the costæ a sort of crenulated appearance; when partially exfoliated the intercostal furrows exhibit a row of fine, regularly arranged pits.

Remarks.—The shell which is here identified as *Chonetes shumardanus* occurs abundantly in the basal Knobstone shales of Kinderhook age, among the "Knobs," south of Louisville, Kentucky. This is the typical locality for DeKoninck's species, and although his original description and illustrations do not exactly fit the shells which commonly occur there, the identification is believed to be correct. The greatest discrepency between DeKoninck's description and the specimens is in the size of the costæ. DeKoninck's statement that 120 occupy the space of 10 millimeters would make 12 in one millimeter, which is about twice as many as the average among the specimens examined. The specimens studied, however, exhibit much variation in this character, the most finely marked specimen having 9 costæ in 1 millimeter. DeKoninck's description also indicates a less convex shell than is usual among our specimens. It is a notable fact that among the specimens studied the lesser convexity, finer costæ, and greater proportional breadth, are characters which are associated, and the writer has sometimes been tempted to refer these alone to DeKoninck's species, and to erect a new species for the narrower, more convex, and more coarsely marked forms which are always by far the most numerous. This procedure has not been followed, however, because both types occur together with intermediate forms, and other characters remain much more constant. The row of minute pits in the intercostal furrows of slightly exfoliated specimens is a conspicuous feature of all the shells, and one which is mentioned and illustrated by DeKoninck. Without access to DeKoninck's type specimens, which are not in America, it is not possible to be absolutely certain what shell he had, or to deter-

mine whether his statement in regard to the size of the costæ is correct, but these shells from the "Button Mould Knobs" cannot be referred to any other described species, and if they are not *C. shumardanus* they must belong to an unnamed form.

This shell has sometimes been confused with *C. illinoisensis*, with which some specimens agree closely in form, size, and size of costæ, but they constantly differ from that species by reason of the transverse markings or crenulations of the costæ which are entirely absent in *C. illinoisensis*. As regards these markings of the shell, *C. shumardanus* resembles *C. logani* and *C. ornatus*, but it differs from both these species in other essential characters.

Horizon.—New Providence shale of the Kinderhook, Kentucky.

CHONETES GREGARIUS Weller

Plate VIII, Figs. 71-72

1901. *Chonetes gregarius* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 149, pl. 12, fig. 2.

Description.—Shell small, usually subelliptical in outline, the length about four-fifths the width, hinge-line usually a little shorter than the greatest width of the shell and the cardinal extremities a little rounded, but in some specimens the cardinal extremities are rectangular and the hinge-line equal to the greatest width of the shell. Lateral margins gently convex or sometimes nearly straight posteriorly, becoming more convex anteriorly and rounding without interruption into the anterior margin, which is gently convex in its median portion. The dimensions of three specimens are: length 4.2 mm., 5.1 mm., and 6.1 mm.; width 5.8 mm., 6 mm., and 8 mm.; convexity 1.5 mm., 1.6 mm., and 2 mm.

Pedicle valve most convex at a point posterior to the middle, from which point the surface curves more abruptly to the beak than to the front margin, the convexity of the valve often extends well out towards the cardinal extremities, the amount of compression of the valve in that region being variable but never excessive; mesial sinus obsolete; the beak small, scarcely extended beyond the cardinal margin; cardinal margin sharply defined, bearing the bases of about two spines on each side of the beak; cardinal area narrow, lying in nearly the plane of the valve, the delthyrium of medium size, closed at its apex by a convex deltidium. Internally a slight median ridge extends anteriorly from the beak, the muscular scars are weakly developed and the surface is papillose towards the anterior and lateral margins.

Brachial valve moderately concave, the greatest concavity posterior to the middle, the surface flattened towards the cardinal extremities;

cardinal area narrow, the cardinal process small. Internally the muscular scars are of only moderate strength, and the surface papillæ are well developed.

Surface of both valves marked by very fine, subangular costæ, which increase by intercalation and by division, about eight or more occupying the space of 1 millimeter, from 75 to 100 being present upon each valve depending upon the size of the valve. Crossing the costæ are minute, concentric, raised lines, which are undeveloped in the intercostal furrows, and which give to the costæ when the surface is perfectly preserved, a crenulate appearance.

Remarks.—In its size and general form this species resembles *C. geniculatus*, but it differs conspicuously from that species in its much finer costæ, there being twice, or more than twice, as many in this species upon shells of equal size. The concentric markings of the shell are also different, they being of the same type as those of *C. logani* and *C. ornatus;* the pedicle valve is less convex and the brachial valve less concave than in *C. geniculatus*. The more minute surface markings of this species are commonly obliterated in the usual condition of preservation of the shells, and only one individual observed among a great number has satisfactorily shown the concentric markings which appear as crenulations of the costæ. In no case have the cardinal spines of the species been observed and upon the great majority of specimens even the spine bases cannot be detected.

Horizon.—Kinderhook.

Chonetes geniculatus White

Plate VIII, Figs. 35-42

1862. *Chonetes geniculata* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 29.
1894. *Chonetes geniculatus* Keyes, Mo. Geol. Surv., vol. 5, p. 53, pl. 38, fig. 3.
1908. *Chonetes geniculatus* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 75, pl. 17, figs. 15-19.

Description.—Shell small, subsemielliptical in outline, rather strongly concavo-convex, the convexity extending well out towards the cardinal extremities, the length about five-sixths of the width, the length of the hinge-line equal to, or a little shorter than, the greatest width of the shell; the cardinal angles rectangular or a little obtuse, lateral margins nearly straight or slightly convex posteriorly, rounding into the anterior margin in front. The dimensions of two specimens are: length 5 mm. and 5.7 mm., width 6 mm. and 6.9 mm., convexity 1.8 mm. and 2 mm.

Pedicle valve most convex near the middle, a little compressed towards the cardinal extremities, but the auriculations are small and not sharply differentiated from the body of the shell; mesial sinus obsolete, but

with the median portion of the valve sometimes a little flattened; cardinal area narrow, slightly concave, lying in nearly the plane of the valve, delthyrium small, closed towards the apex by the convex deltidium; the cardinal margin sharply defined, bearing about three spines on each side of the beak which are directed obliquely outward; the beak small and but slightly extended beyond the cardinal margin, the umbo inconspicuous.

The brachial valve moderately concave in the median portion, the greatest concavity near the middle, becoming flattened towards the cardinal extremities; the cardinal area narrower than that of the opposite valve and meeting it in a widely obtuse angle or lying in nearly the same plane; the posterior extremity of the cardinal process tripartite and filling the basal portion of the delthyrium of the opposite valve.

Surface of both valves marked by depressed, rounded costæ, about four or five in the space of one millimeter, and from 35 to 40 upon each valve, these costæ are commonly indistinct posteriorly and are frequently nearly or quite obsolete to nearly the margin of the valves; upon the brachial valve a small, longitudinal, node-like prominence is present just in front of the middle of the cardinal margin. Aside from the costæ the surface is marked by exceedingly fine concentric markings and by a variable number of much stronger lines of growth which are sometimes nearly equally distributed, but are more often crowded towards the front.

Remarks.—This little shell is similar in general form to *C. logani*, but it is smaller and has more nearly obsolete costæ which are not crenulated as are those of that species. It is associated with *C. ornatus*, from which it may be easily distinguished by its smaller size, greater relative convexity and much less sharply defined costæ.

Horizon.—Louisiana limestone.

Chonetes burlingtonensis Weller

Plate VIII, Figs. 18-19

1901. *Chonetes burlingtonensis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 184, pl. 16, fig. 9.

Description.—Shell semielliptical in outline, the length equal to two-thirds the width, the greatest width along the hinge-line, the cardinal extremities nearly rectangular, the lateral margins nearly straight or slightly convex posteriorly, becoming more strongly curved anteriorly and passing into the anterior margin which becomes more gently convex in its median portion. The dimensions of the type specimen are: length 9 mm., width 13.5 mm., convexity 3 mm.

Pedicle valve most convex posterior to the middle, the surface curving rather abruptly to the beak and much more gently to the anterior margin,

compressed towards the cardinal extremities but the auriculations not sharply differentiated from the body of the valve, in the median portion of the valve the surface is somewhat flattened, but is not depressed in a median sinus; the beak is small and inconspicuous, the umbo smooth at its apex, scarcely extending beyond the cardinal line; cardinal area and delthyrium not observed, the cardinal margin sharply defined, bearing two or three spines on each side of the beak.

Brachial valve moderately or rather deeply concave, the greatest concavity posterior to the middle, the surface flattened or only slightly concave towards the cardinal extremities; the cardinal area very narrow; the plications do not extend to the beak but leave a small, smooth region at the apex of the valve, in the middle of which, adjacent to the hinge-line, is a small, longitudinal, sharply differentiated, node-like prominence.

Surface of both valves marked by narrow, sharply elevated, rounded costæ, which increase by bifurcation on the pedicle valve and by implantation on the brachial valve; they are separated by narrower intercostal furrows; from three to five costæ occupy the space of one millimeter, about 100 being present at the margin which originate from the bifurcation of about 25 initial ones. Aside from the costæ the surface is marked by minute, concentric lines which are more strongly developed across the intercostal furrows than upon the costæ themselves, and are often nearly or quite obsolete.

Remarks.—This species resembles *C. illinoisensis*, but is smaller, with coarser costæ which are separated by proportionally narrower and deeper intercostal furrows. The concentric markings also differentiate the species from *C. illinoisensis*, as well as the smaller number of cardinal spines. The species differs from *C. logani*, with which it is associated, in its larger size, proportionally less convexity, larger number of costæ and less conspicuous concentric markings which are not restricted to the tops of the costæ.

Horizon.—Kinderhook.

Chonetes planumbonus Meek and Worthen

Plate VIII, Figs. 58-62

1860. *Chonetes planumbona* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 450.

1866. *Chonetes planumbona* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 253, pl. 18, figs. 1a-d.

Description.—Shell concavo-convex, subsemielliptical in outline, the greatest width along the hinge-line, the cardinal extremities nearly rectangular, the length from two-thirds to three-fourths the width, the lateral margins nearly straight posteriorly, becoming more convex towards

the front and rounding regularly into the anterior margin which is somewhat straightened in its median portion. The dimensions of two specimens are: length 8.9 mm. and 8.7 mm., width 11.9 mm. and 11.1 mm., convexity 2.8 mm. and 2.8 mm.

Pedicle valve most convex near or a little in front of the middle, the surface commonly curving more abruptly to the anterior margin than to the beak, slightly compressed towards the cardinal extremities but only obscurely auriculate; mesial sinus obsolete, although the mesial portion of the valve is sometimes slightly flattened; umbonal region somewhat flattened, the beak not produced beyond the cardinal margin; the cardinal margin sharply defined, bearing four or five oblique spines on each side of the beak; cardinal area rather broad and flat, the delthyrium broadly triangular with a small deltidium closing its apical portion, the lateral margins sharply defined, bearing four or five, probably oblique, spines on each side of the beak.

Brachial valve only moderately concave, the greatest concavity in front of the middle, becoming a little flattened towards the cardinal extremities; the cardinal area very narrow. Internally the cardinal process is of moderate size and is flanked by a pair of widely divergent, rather short ridges, in the outer sides of which the dental sockets are excavated; the muscular scars rather indistinct; the surface covered with elongate papillæ which are arranged in radial series and grow more prominent towards the outer margins of the valve.

Surface of both valves appearing nearly smooth to the naked eye, but a lens shows that obscure and more or less discontinuous radiating costæ are present, and that these are crossed by minute, raised, flexuous and discontinuous concentric markings.

Remarks.—This species has only been observed from the typical locality in Monroe County, Illinois, and in Ste. Genevieve County, Missouri, where it sometimes occurs in abundance in certain of the limestone layers. The species is easily recognized because of the nearly obsolete surface markings. The raised concentric markings of the shell somewhat resemble those of *C. logani*, but they do not have the regularity of the similar markings of that species, and are more nearly continuous because of the nearly obsolete radiating costæ. Other characters which distinguish the species are the slight auriculation of the shell and the anterior position of the greatest convexity of the pedicle valve.

Horizon.—Upper Keokuk limestone.

Genus *CHONOPECTUS* Hall and Clarke

Description.—Shell concavo-convex, broader than long, the greatest width at or near the hinge-line; cardinal area of the pedicle valve narrow, its lateral margins bearing a single row of slightly divergent spines which

increase in length towards the cardinal extremities. The beak of the pedicle valve is compressed and flattened, and sometimes slightly distorted from attachment in early growth. External surface of both valves marked by exceedingly fine, radiating costæ, which are crossed by a double series of oblique concentric lines. The concentric markings are best developed on the brachial valve.

Remarks.—In its general form, and in its cardinal spines this genus does not differ essentially from *Chonetes*, but it can be distinguished at once from that genus by means of its surface markings. A single species of the genus is known and the condition of preservation in which it has been observed is not such as to allow the internal characters of the shell to be clearly distinguished, but the inner surface of the valves apparently lack the papillæ which are so constant a feature in *Chonetes*.

Chonopectus fischeri (Norwood and Pratten)

Plate VIII, Fig. 73; Plate LXXXIII, Figs. 21-22

1855. *Chonetes Fischeri* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil. (2), vol. 3, p. 25, pl. 2, fig. 3.
1858. *Chonetes fischeri* Hall, Geol. Iowa, vol. 1, pt. 2, p. 517, pl. 7, figs. 1a-e.
1869. *Chonetes Fischeri* Winchell, Safford's Geol. Tenn., p. 443.
1870. *Chonetes Fischeri* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 250.
1883. *Chonetes Fischeri* Hall, Rep. N. Y. State Geol. for 1882, pl. (16) 47, figs. 17-31.
1892. *Chonopectus Fischeri* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 20, figs. 24-27.
1892. *Chonopectus Fischeri* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 15B, figs. 20-23; pl. 16, figs. 17, 31.
1900. *Chonopectus fischeri* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 69, pl. 1, fig. 17.
1901. *Chonopectus fischeri* Weller, Trans. St. Louis Acad. Sci., vol. 11, pp. 150, 151, 154, pl. 12, fig. 1, pl. 13, fig. 17.

Description.—Shell concavo-convex, subelliptical or subcircular in outline, usually wider than long, the hinge-line usually a little shorter than the greatest width of the shell, the hinge extremities subrectangular or a little rounded. The lateral margins gently convex or nearly straight posteriorly, curving more rapidly towards the front and passing without interruption into the broadly rounded anterior margin. The dimensions of two individuals are: length 17 mm. and 21 mm., width 24.8 mm. and 30.8 mm., convexity of pedicle valve 3.5 mm. and 5 mm.

Pedicle valve most convex near the middle, becoming moderately compressed towards the cardinal extremities, with no mesial sinus or mesial flattening of the valve; the umbonal region usually a little flattened, the beak scarcely protuberant beyond the cardinal margin; the cardinal margin sharply defined, bearing about four, slender, obliquely curved spines

on each side of the beak. The cardinal area, delthyrium, and internal characters of the valve not observed.

Brachial valve moderately concave with the greatest concavity near the middle, the surface becoming flattened towards the cardinal extremities; at the beak or initial point of the valve, close to the cardinal margin, is a small, round, node-like protuberance. The cardinal area, cardinal process, and internal features of the shell not observed.

Surface of both valves marked by fine, thread-like, wavy, discontinuous, more or less irregular, radiating costæ, about six of which occupy the space of one millimeter, these are crossed by still finer concentric striæ which give to the uninjured shell surface a finely reticulated ornamentation when examined under a lens. The older half of the shell is also frequently marked by two sets of more or less conspicuous concentric wrinkles which cross each other in the manner of the engine-turned markings on a watch case. Irregular concentric lines of growth in the form of more or less prominent wrinkles are not infrequently present.

Remarks.—This species is the only known member of the genus, and is especially characteristic of the Kinderhook beds 2, 3 and 4 of the Burlington, Iowa, section. The specimens sometimes occur in enormous numbers in the lower of these beds, a yellow sandstone, but it always occurs in this bed in the condition of modified casts and moulds which do not exhibit the true characters of the surface markings to best advantage. These markings are better shown on specimens from the limestone beds No. 3 and 4, except the two sets of crossed concentric marks which usually are more conspicuous upon the sandstone specimens, and which seem to be more conspicuous upon the brachial than upon the pediele valves.

The species is exceedingly variable in the proportional length and breadth of the shell, some specimens being considerably longer than wide, while others are conspicuously transverse. The specimens whose dimensions have been given are of about average size and form.

Horizon.—Kinderhook.

Genus *PRODUCTELLA* Hall

Description.—Shells below medium size, more or less deeply concavo-convex, the hinge-line straight, equaling or shorter than the greatest width of the shell. Pediele valve convex, the beak more or less incurved, dependent upon the amount of convexity of the valve; a narrow cardinal area present, with the delthyrium closed by a deltidium; cardinal teeth present. Brachial valve concave, furnished with dental sockets and socket plates. External surface of the plates spinose, the spines usually arranged more or less irregularly, also marked by irregular, concentric or radiating marks, or by both.

Remarks.—The characters commonly designated as the essential features of *Productella* as distinguished from *Productus*, viz., the narrow cardinal area and weakly developed articulating hinge-teeth and sockets, can rarely be distinguished upon the specimens, and in actual practice the type of surface markings of the shell is commonly relied upon for the recognition of the genus. In the genus *Productus* these markings are always clear cut and well defined, while in *Productella* there is commonly an indefiniteness about them which is in strong contrast to the condition in *Productus*. In *Productella* the radiating markings are commonly more or less discontinuous, often elongate, node-like elevations of the surface, rather than distinct, continuous costæ. The surface spines are also commonly arranged in a more or less irregular manner in *Productella*, while in *Productus* each species exhibits a fairly definite arrangement of its surface spines.

PRODUCTELLA CONCENTRICA (Hall)

Plate XIX, Figs. 22-34

1857. *Productus concentricus* Hall, 10th Rep. N. Y. State Cab. Nat. Hist., p. 180.
1858. *Productus shumardianus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 499, pl. 7, fig. 1 (not pl. 3, fig. 9).
1858. *Productus concentricus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 517, pl. 7, fig. 3.
1860. *Productus Cooperensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 640.
1862. *Producta concentrica* Winchell, Proc. Acad. Nat. Sci. Phil., p. 411.
1865. *Producta concentrica* Winchell, Proc. Acad. Nat. Sci. Phil., p. 114.
1865. *Producta Cooperensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 115.
1867. *Productella shumardiana* Hall, Pal. N. Y., vol. 4, p. 157, pl. 23, figs. 6-8.
1869. *Producta concentrica* Winchell, Safford's Geol. Tenn., p. 443.
1870. *Producta concentrica* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 249.
1888. *Productus concentricus* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 33, pl. 6, fig. 16.
1888. *Productus* (*Productella*) *shumardianus* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 32, pl. 7, fig. 18; pl. 12, figs. 6, 43.
1892. *Productella Shumardiana* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17, fig. 7.
1899. *Productella cooperensis* Girty, Mon. U. S. Geol. Survey No. 32, p. 528, pl. 68, figs. 8a-e, 9a-b.
1901. *Productella concentrica* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 184, pl. 16, figs. 12-14.

Description.—Shell below medium size, length and width sub-equal, or a little longer than wide, the hinge-line shorter than the greatest width, the cardinal extremities angular. The dimensions of a nearly complete specimen are: length from hinge-line to front margin 13 mm., length from umbonal region of pedicle valve to front margin 15 mm., greatest width 15 mm., length of hinge-line 11 mm., convexity of pedicle valve 10.2 mm.

Pedicle valve gibbous, arched from the umbonal region to the anterior margin with the posterior curvature somewhat more convex than the anterior, the umbonal region prominent and strongly protuberant beyond the hinge-line, the surface curving abruptly to the cardinal margin and less abruptly to the lateral and anterior margins, rather abruptly deflected towards the cardinal extremities to form small, compressed auriculations; mesial sinus obsolete; the beak strongly incurved.

Brachial valve moderately concave in its visceral portion, with the cardinal extremities somewhat deflected, anteriorly and laterally the valve is abruptly curved, or subgeniculate in passing from the visceral region to the produced portion of the valve, so that the entire valve becomes very deeply concave at maturity.

Surface of both valves usually marked by strong, concentric, wrinkle-like folds in the visceral region, which become inconspicuous or obsolete upon the produced portion of the shell; surface of the pedicle valve more or less distinctly marked by elongate nodes, especially upon the produced portion of the shell, which are frequently more or less connected longitudinally to form rather broad, rounded, depressed, longitudinal costæ which are irregular in their development, and not infrequently nearly obsolete; the brachial valve marked by shallow, more or less elongate depressions which are at times connected to form somewhat discontinuous, longitudinal furrows, these markings being more conspicuous upon the produced portion of the valve but being likewise present upon the visceral surface; they are more constant than the corresponding costæ of the pedical valve; entire surface of both valves marked by fine, concentric lines of growth.

Remarks.—This species was originally described from an external impression of a brachial valve from the upper yellow Kinderhook sandstone at Burlington, Iowa. *Productella shumardiana* was described from two specimens, a pedicle valve from the same horizon and locality from which the type of *P. concentrica* was obtained, and a brachial valve from the Louisiana limestone of Clarksville, Missouri; the first of these specimens is undoubtedly a member of the same species as the type of *P. concentrica*, while the second specimen is an example of *P. pyxidata*. *Productus cooperensis* was described from the Chouteau limestone of central Missouri, where it is a common species; many examples of both the brachial and pedicle valves have been examined and they exhibit no characters by means of which they can be separated from *P. concentrica*. All three of these forms, except one of the type specimens of *P. shumardiana* must be considered as synonyms, and for this form the name *P. concentrica* holds priority. It has sometimes been suggested that the species should be made to include also *P. pyxidata*, but that species is clearly distinct, *P. concentrica* being characterized by its narrower form and its much

more strongly convex pedicle valve, with much smaller cardinal auriculations, the surface markings of the two shells are also distinctly different. The species agrees more closely with the middle Devonian *P. spinulicosta*, and it has sometimes been suggested that these two forms are identical, both having the same general form, size, and surface markings. It is possible that this interpretation should be held, but for the present these Mississippian shells will be considered as distinct from the middle Devonian form, although an entirely satisfactory method of distinguishing them cannot be pointed out.

The species exhibits considerable variation in size and in the strength of the development of the surface markings. It sometimes attains a length and width of 20 mm. or more. The variation in the surface markings is more conspicuous in the longitudinal features, although the concentric folds of the visceral portion of the pedicle valve are sometimes almost obsolete; the surface features of the brachial valve are usually more constant than those of the pedicle valve.

Horizon.—Kinderhook.

Productella pyxidata Hall

Plate XIX, Figs. 1-21

1858. *Productus pyxidatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 498, pl. 3, figs. 8a-e.
1858. *Productus shumardianus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 499, pl. 3, fig. 9 (not pl. 7, fig. 1).
1883. *Productella pyxidata* Hall, Rep. N. Y. State Geol. for 1882, pl. (17) 48, fig. 34.
1892. *Productella pyxidata* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 21, figs. 20, 23.
1892. *Productella pyxidata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17, fig. 34, pl. 17A, fig. 14.
1894. *Productella pyxidata* Keyes, Mo. Geol. Surv., vol. 5, p. 52, pl. 38, figs. 4a-d.
1908. *Productella pyxidata* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 77, pl. 17, figs. 5, 30-36.

Description.—Shell usually below medium size, and wider than long, subsemielliptical in outline, the hinge-line a little shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete specimen of average size are: length from hinge-line to front margin 14.4 mm., length from umbonal region of pedicle valve to front margin 16.4 mm., greatest width 19.1 mm., length of hinge-line ±17 mm., convexity of pedicle valve 17 mm., depth of visceral cavity 4.6 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the umbonal region projecting somewhat beyond the hinge-line, the surface curving abruptly from the umbonal region to the cardinal margin, curving less abruptly to the lateral margins and more gently to

the anterior margin, strongly and rather abruptly compressed towards the cardinal extremities; mesial sinus obsolete; beak small and incurved.

Brachial valve rather deeply concave, with the surface somewhat deflected towards the cardinal extremities, the concavity rather narrow at the beak and broadening rapidly anteriorly. Internally the cardinal process is rather small, bifid, with each division longitudinally excavated upon its posterior and outer surfaces; from the base of the cardinal process a pair of ill-defined, low, broadly diverging ridges extend for one-third or more the distance to the postero-lateral margins, their posterior slopes being more abrupt and constituting the rudimentary dental sockets; a broad, low ridge extends anteriorly along the median line of the valve from the junction of the two diverging ridges, which is soon abruptly constricted to a narrow and low median septum reaching to or beyond the middle of the valve; the brachial impressions of moderate strength, usually reaching a little more than two-thirds the distance from their bases to the lateral and anterior margins; the inner surface covered throughout, except upon the brachial impressions, the median septum and the region adjacent to the base of the cardinal process, by closely crowded papillæ or tubercles, arranged more or less definitely in radiating series.

Surface of both valves marked by more or less crowded, concentric lines of growth. Spine bases exceedingly variable in their development; on the pedicle valve they are sometimes nearly absent except a few near the cardinal margin, and again they are more or less crowded and usually arranged in radiating series over the entire surface, sometimes they are strong and elongate and the radiate arrangement is so well defined that the surface of the valve appears almost to be marked by radiating costæ; upon the brachial valve the spine bases are never so conspicuous.

Remarks.—This is a highly characteristic species from the Louisiana limestone, and while it is exceedingly variable in some of its features, especially its surface markings, it is so different from other species of our faunas that there can be no difficulty in recognizing it.

Horizon.—Louisiana limestone.

Productella nummularis (Winchell)

Plate XIX, Figs. 39-41

1863. *Strophalosia ? nummularis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 4.

1900. *Productella nummularis* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 71, pl. 1, figs. 9-10.

Description—Shell of medium size, subcircular in outline, a little wider than long, the hinge-line about two-thirds the width of the shell, the cardinal extremities obtusely subangular or a little rounded. The dimensions of an imperfect pedicle valve are: length 27 mm., width ±24 mm.,

convexity 7 mm. The dimensions of a brachial valve are; length 21 mm., width 25 mm., length of hinge-line 16 mm.

Pedicle valve depressed convex, with the greatest convexity near or posterior to the middle, the surface curving with a gently convex curvature to the lateral and anterior margins and somewhat compressed towards the cardinal extremities, the curvature from the umbonal region to the cardinal margin on each side of the beak rather abrupt, the umbonal region only very slightly produced posteriorly beyond the hinge-line; mesial sinus obsolete; beak small and incurved.

Brachial valve nearly flat, with a shallow, narrow concavity at the beak whose lateral margins diverge rapidly anteriorly and become less well defined; mesial fold obsolete. Internally the cardinal process is small and bifid, lying in the plane of the valve and projecting beyond the hinge-line into the umbonal cavity of the opposite valve; a low median ridge extends from the base of the cardinal process nearly to the middle of the valve.

The surface of the pedicle valve is covered by innumerable, fine and delicate spines which attain a length of 5 mm. or more; the brachial valve is marked throughout by small crowded pits which may represent the position of similar fine spines, although the spines themselves have not been observed; both valves marked by conspicuous and nearly regular, concentric lines of growth.

Remarks.—In the condition of preservation in which this species occurs, in a fine, yellow sandstone of the Kinderhook, the fine surface spines are rarely discernable, but the surface of the pedicle valve possesses a finely granular texture which is more or less conspicuous; the most conspicuous surface markings are the very regular concentric lines of growth. The species is characterized by its subcircular outline, being truncated on the posterior side by the hinge-line; by the depressed-convex pedicle valve and the nearly flat brachial valve. The species resembles *P. pyxidata* but it attains a larger size, with relatively shorter hinge-line and with very different surface markings; the brachial valve is also much flatter.

Horizon.—Chonopectus sandstone of the Kinderhook.

Productella sublævis n. sp.

Plate LXXXIII, Figs. 18-20

Description.—Shell large, depressed concavo-convex, wider than long, the hinge-line a little shorter than the greatest width of the shell, lateral and anterior margins describing a regular, subelliptical curve, one side of the ellipse, that on the posterior side of the shell, being incomplete. The dimensions of the best preserved brachial valve observed, a small individual, are: length 25 mm., width 33 mm., convexity 8 mm.,

length of hinge-line 26 mm. The dimensions of a larger brachial valve, more nearly the usual size of the species, are: length 31 mm., width 42 mm., concavity 8.5 mm., length of hinge-line 31.5 mm.

The pedicle valve is regularly convex except postero-laterally, where the surface towards the cardinal extremities is somewhat depressed, so that the curve of the surface from the highest point of the shell to the cardinal angles is at first gently convex and then concave. The surface of the valve is marked by obscure, depressed, elongate nodes indicating the position of spine bases, these nodes are more numerous towards the front of the shell, the posterior portion being almost entirely free from them in the best specimens observed.

The concavity of the brachial valve follows rather closely the curve of the pedicle valve so that the visceral cavity is very shallow, the surface of this valve seems to be more completely covered with the obscure, elongate spine bases than the pedicle valve, and it is also marked by faint concentric lines, especially towards the cardinal line.

Remarks.—This species is one of the more common forms in the yellow sandstone at Kinderhook, Illinois, but most of the specimens observed have been somewhat weathered, so that but little more than the general form and proportions can be recognized. Those specimens that do preserve the surface characters, however, show that the shell was exceptionally smooth for members of this genus, the node-like spine bases being rather obscure in all cases. The species is larger than any of the heretofore recognized Kinderhook species, and is equalled in size by but few Devonian forms. It resembles *P. onusta* Hall from the Chemung beds of New York, but is less convex, with a proportionally shorter hinge-line, it also attains a larger size than that species, judging from the illustrations published by Hall.[1]

Horizon.—Kinderhook.

Genus *PRODUCTUS* Sowerby

Description.—Shells varying in size from small to very large, deeply concavo-convex in form, usually produced anteriorly, the hinge-line straight and usually equaling the greatest width of the shell, commonly auriculate at the cardinal extremities. Pedicle valve without cardinal area or hinge-teeth, the two valves held together at the cardinal margin by the strongly incurved beak of the pedicle valve. Brachial valve more or less concave, or nearly flat in the visceral region, becoming more strongly curved towards the anterior and lateral margins; cardinal area, dental sockets and socket plates absent or very rudimentary, the cardinal process large and strong, extending far beyond the hinge-line into the

[1] Pal. N. Y., vol. 4, pl. 26, figs. 29-42 (1867).

umbonal cavity of the opposite valve. Surface of both valves marked by distinct, subequal, regular or flexuose, and usually continuous radiating costæ, and by concentric undulations or wrinkles which are commonly restricted to the posterior portion of the valves or to the region towards the cardinal extremities. More or less elongate, hollow spines are present in various situations upon the shell surface, usually most conspicuously developed in the region of the cardinal extremities.

Remarks.—The genus *Productus* includes one of the largest groups of species of any genus of Mississippian brachiopods, and, as heretofore commonly interpreted, has been made to include several more or less widely diverse types of shells. One of these subordinate groups of species, that typified by *P. biseriatus* and *P. punctatus*, has been separated from *Productus* in the present report as a distinct genus under the name *Echinoconchus*. Still another subordinate group, of which *P. cora* is a typical representative, might also, perhaps, be made to constitute a distinct genus, although that has not been done here. Recently one of our species, *P. elegans*, has been made the type of still another genus, *Diaphragmus*, by Girty.

Productus burlingtonensis Hall

Plate IX, Figs. 1-10

1858. *Productus flemingi* var. *burlingtonensis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 598, pl. 12, figs. 3a-g.
1883. *Productus Flemingi* var. *Burlingtonensis* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, figs. 6-8.
1892. *Productus Flemingi* var. *Burlingtonensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, figs. 6-8.
1894. *Productus burlingtonensis* Keyes, Mo. Geol Surv., vol. 5, p. 41.

Description.—Shell of medium size or somewhat larger, broader than long, the hinge-line equaling or greater than the greatest width of the body of the shell, the lateral margins sinuate in front of the cardinal extremities, convexly rounding anteriorly into the anterior margin which is sinuate in its central portion. The dimensions of a nearly complete pedicle valve are: length from the hinge-line to the anterior margin 24 mm., length from the umbonal region to the anterior margin 33 mm., length of hinge-line 41.5 mm., width of body of shell at its mid-length 36 mm., convexity of pedicle valve 25 mm.

Pedicle valve strongly ventricose, the umbonal region protruding conspicuously posteriorly beyond the hinge-line, the beak strongly incurved so that it lies nearly opposite the center of the valve, the surface curving abruptly to the cardinal and lateral margins and a little more gently to the anterior margin, auriculate at the cardinal extremities, the auriculations of moderate size and rather abruptly differentiated from the body of the valve, their surface convex antero-posteriorly with the curvature

more abrupt to the cardinal margin; mesial sinus originating in the umbonal region, of only moderate depth and width, rounded in the bottom and ill defined laterally. Surface of the valve marked by rounded, radiating costæ which increase by bifurcation and intercalation posteriorly, but anterior to the middle they usually continue without further division to near the front margin, where they tend to become obsolete, the distance between the costæ varies from .5 to 1.5 mm. in the anterior portion of the valve, about 1 mm. being the usual distance from center to center, posteriorly they are more closely crowded; on the posterior slope of the valve the radiating costæ are crossed by distinct, rather regular, wrinkle-like concentric markings, giving to that portion of the valve a distinctly semireticulate ornamentation; spine bases are either nearly obsolete upon the surface of the valve or they are scattered irregularly upon the anterior and lateral slopes, one or more sometimes being present upon the auricular extensions of the valve; in front of the spine bases, when present, two or more of the surface costæ are sometimes united to form a broader costa which continues to the anterior margin. Internal characters of the pedicle valve not observed.

Brachial valve gently concave in its posterior portion, flattened towards the cardinal extremities opposite the auriculations of the other valve, anteriorly and antero-laterally the valve is more abruptly curved and is produced nearly in contact with the anterior and antero-lateral portions of the opposite valve; anteriorly the mesial portion of the valve is elevated in a low, rounded, mesial fold to correspond with the sinus of the opposite valve. Surface of the valve marked by radiating costæ which are less distinctly developed than those of the opposite valve, and in the posterior portion by concentric, wrinkle-like markings which are also less distinct than those of the pedicle valve; no spine bases have been observed upon this valve, although they may be present in some cases. Internally the cardinal process is large and strong, its entire length being produced posteriorly beyond the hinge-line into the protuberant umbonal portion of the opposite valve; it is bifid at its extremity and is flanked at its base by a thickened ridge on either side which extends laterally nearly parallel with and close to the cardinal margin, distally these lateral ridges become broader and less differentiated from the general surface of the valve, but the thickening extends to the cardinal extremities; anteriorly from the cardinal process a low, thin median septum reaches to near the middle of the valve; on either side of the median line where the valve begins to approach more nearly to the curvature of the opposite valve, the inner surface is covered with fine, crowded, spinule-like papillæ which are inclined anteriorly.

Remarks.—This species is characterized by the strongly convex pedicle valve, the deep visceral cavity between the two valves, the usually small

auricular extensions of the pedicle valve, and the presence of a mesial sinus. Th auricular extensions of the shell are usually more or less imperfectly preserved and oftentimes appear to be essentially wanting, and in such examples the hinge-line is apparently shorter than the greatest width as stated by Hall in the original definition of the species, but in all specimens examined in which the auricular extensions are completely preserved, the hinge-line is longer than the width of the shell anteriorly. The species most closely resembles *P. inflatus,* but in that species the auricular extensions are somewhat more conspicuous, the mesial sinus is usually narrower and deeper, and the semireticulate markings of the posterior portion of the pedicle valve are much less conspicuous.

Horizon.—Burlington limestone.

Productus fernglenensis Weller

Plate IX, Figs. 11-17

1909. *Productus fernglenensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 299, pl. 12, figs. 14-17.

Description.—Shell of medium size or a little larger, wider than long in most specimens, but sometimes becoming longer than wide in old examples, hinge-line a little shorter than the greatest width, the anterior margin regularly rounded or sometimes a little sinuate in the middle. The dimensions of an incomplete specimen are: length from hinge-line to front margin 21.3 mm., length from umbonal region to front margin 27 mm., length of hinge-line 27.5 mm., greatest width 33.5 mm., convexity of pedicle valve 23 mm. The largest specimen observed has a length of 39 mm. from the umbonal region to the front margin, with a width of 35 mm.

Pedicle valve gibbous, the umbonal region broadly pointed towards the beak and strongly protuberant beyond the hinge-line, the mesial portion of the valve broadly flattened from the umbonal region to the front, the surface very gently convex, nearly straight or slightly concave transversely, rounding more abruptly into the lateral slopes which drop nearly vertically to the lateral margins, the auriculations small but rather well defined from the lateral slopes; mesial sinus wanting or only slightly depressed, and ill defined laterally; the beak strongly incurved. Surface covered by rounded, radiating costæ, usually 1 mm. or less in width, which increase by bifurcation upon the posterior slope, on the anterior slope they either continue without division or sometimes break up into two or more in front of the spine bases and continue to the front with a fasciculate arrangement, often becoming coalescent near the margin; upon the posterior slope the radiating costæ are crossed by rather conspicuous, concentric, wrinkle-like markings which are com-

monly stronger towards the cardinal margins, giving to this portion of the valve a decidedly semireticulate appearance; the entire surface, when well preserved, marked by fine concentric lines of growth. Spine bases usually inconspicuous, sometimes apparently absent, when present they are rather coarse and occur almost entirely upon the anterior and lateral slopes of the valve with occasionally one or more upon each auriculation.

Brachial valve flattened in the visceral portion with the auricular portions only slightly differentiated, becoming more concave anteriorly and laterally and with the marginal produced region curving rather abruptly to conform with the anterior and lateral portions of the opposite valve; mesial fold, when present, originating posterior to the middle of the valve, it is low, broad and illdefined laterally, not infrequently absent. Surface marked by radiating costæ similar to those of the opposite valve, and in the visceral portion by well defined, concentric, wrinkle-like markings which make it distinctly semireticulate. Internally the cardinal process is rather short, subtriangular in form with a median groove which does not divide it into two distinct lobes; it projects posteriorly into the umbonal cavity of the opposite valve; other internal characters not well preserved.

Remarks.—This species resembles *P. burlingtonensis* in general form and size, but it differs from that species in the lower curvature of the pedicle valve, and especially in the absence or slight development of the mesial sinus of the pedicle valve. The fasciculate arrangement of the plications anterior to the base of surface spines upon the anterior slope is also a character which differentiates the species from *P. burlingtonensis,* although it is a character which is not uniformly present. The species differs from *P. costatus* of the Pennsylvanian faunas, in the smaller auriculations and in the absence of the row of spine bases, which in that species marks the inner margin of each auriculation.

Horizon.—Fern Glen formation and Pierson limestone of the Kinderhook.

Productus arcuatus Hall

Plate XIII, Figs. 1-8; ?9-12

1858. *Productus arcuatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 518, pl. 7, figs. 4a-b.
1870. *Producta arcuata* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 250.
1883. *Productella arcuata* Hall, Rep. N. Y. State Geol., for 1882, pl. (17) 48, figs. 31, 32.
1888. *Productus arcuatus* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 31, pl. 3, fig. 18.
1892. *Productella arcuata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17, figs. 31, 32.
1894. *Productus arcuatus* Keyes, Mo. Geol. Surv., vol. 5, p. 40.

1901. *Productus arcuatus* Weller, Trans. St. Louis Acad. Sci, vol 11, p. 160, pl. 14, fig. 23; p. 185, pl. 16, fig. 15.

Description.—Shell below medium size, usually longer than wide, the greatest width near the mid-length, the hinge-line shorter than the greatest width, the cardinal extremities angular or sometimes a little rounded. The dimensions of a nearly perfect pedicle valve are: length from hinge-line to front margin 15.5 mm., length from umbonal region to front margin 20.3 mm., greatest width 19 mm., length of hinge-line 14 mm., convexity 12.5 mm.

Pedicle valve gibbous, arched longitudinally with the longer curve on the anterior side, the umbonal region rather broad and strongly protuberant beyond the hinge-line, the mesial portion of the valve rather broadly flattened or very gently convex transversely, the lateral slopes curving abruptly to the lateral and cardinal margins, the auriculations at the cardinal extremities small, flattened vertically in mature shells but in young individuals the surface of the auriculations is more nearly horizontal; mesial sinus obsolete; beak strongly incurved. Surface of the valve covered by rounded, radiating costæ, usually measuring about 1 mm. from center to center upon the anterior slope, they increase usually by bifurcation upon the posterior slope of the valve and continue across the anterior slope either without division or rarely dividing, occasionally two costæ coalesce towards the margin of the valve; on the posterior slope concentric, wrinkle-like markings are present, best developed towards the cardinal margin and becoming fainter across the median portion of the valve; the entire surface covered by fine, concentric lines of growth when the shell is not exfoliated. Spine bases usually not conspicuous, sparsely scattered over the entire surface but becoming more abundant upon the outer half of the valve. Internal characters not seen.

Brachial valve not observed.

Remarks.—This species is characterized by its small size, the great convexity of the pedicle valve with the nearly vertical lateral slopes, the absence of a mesial sinus, the short hinge-line, and small auriculations whose surface is more nearly vertical than horizontal. In some respects the shell resembles a small example of *P. burlingtonensis* but it differs from that species in the absence of a median sinus and in the vertical flattening of the auriculations.

Horizon.—Kinderhook.

Productus sedaliensis n. sp.

Plate XIV, Figs. 1-7

1891. *Productus blairi* Miller, Adv. Sheets 17th Rep. Geol. Surv. Ind., p. 79, pl. 13, fig. 17 (not fig. 16).

1892. *Productus blairi* Miller, 17th Rep. Geol. Surv. Ind., p. 689, pl. 13, fig. 17 (not fig. 16).

Description.—Shell of medium size or somewhat larger, broader than long, the hinge-line shorter than the greatest width. The dimensions of a nearly complete specimen are: length from hinge-line to front margin 28.5 mm., length from umbonal region to front margin 33 mm., length of hinge-line 29 mm., greatest width 36 mm., convexity of pedicle valve 22.5 mm.

Pedicle valve gibbous, arched from the umbonal region to the front margin with the curvature shorter and a little more abrupt posteriorly, the umbonal region rather broadly pointed towards the beak and produced prominently beyond the hinge-line, the median portion of the valve broadly flattened from the umbonal region to the anterior margin, this surface curving abruptly into the lateral slopes, distinctly flaring towards the lateral and anterior margins, the auriculations of moderate size and not abruptly differentiated from the lateral slopes; mesial sinus obsolete; beak strongly incurved. Surface marked by strong, rounded, radiating costæ which divide frequently upon the posterior slope, rarely or not at all upon the anterior and lateral slopes, until approaching the flaring margins, where bifurcations again occur, the size of the costæ upon the anterior slope is usually about 1 mm. or somewhat more from center to center; crossing the radiating costæ upon the posterior slope of the shell are more or less conspicuous, concentric, wrinkle-like markings which give to that surface a distinctly semireticulate appearance; the entire surface, when well preserved, covered by faint, concentric lines of growth. Spine bases usually inconspicuous, when best preserved they are scattered somewhat sparsely over the anterior and lateral slopes, with sometimes, and perhaps always if well preserved, a row along the cardinal margin.

Brachial valve gently concave in the visceral region with the auricular portions rather broad but not sharply defined, anteriorly and laterally the curvature becomes greater as the surface passes into the produced portion lying in contact with the opposite valve; the mesial portion of the valve, from near the middle of the visceral region, is usually slightly raised above the surface on either side in a slight, rather broad, ill-defined mesial fold. Surface marked by radiating series of somewhat elongate pits near the beak, which are interrupted intercostal furrows, but the markings quickly change into distinct and rather strong radiating costæ similar to those of the opposite valve, which increase by bifurcation and intercalation; the visceral portion of the valve crossed by concentric wrinkle-like markings, and the entire surface crossed by fine, concentric lines of growth which are much stronger than those of the opposite valve.

Remarks.—Miller interpreted an external impression of a brachial valve of this species as a pedicle valve of his species *P. blairi*, and illustrated it as one of the types of that species. The specimen figured by Miller as an external impression of the brachial valve of *P. blairi* is properly

interpreted and may consequently be assumed as the type of that species. The specimen incorrectly interpreted by Miller belongs to the hitherto undefined species here described. This species resembles both *P. burlingtonensis* and *P. fernglenensis* in some respects, but is clearly distinct from either. It can at once be distinguished from *P. fernglenensis* by its somewhat coarser costæ, by the entire absence of mesial sinus, by the distinctly flaring lateral and anterior margins, and by the more or less interrupted intercostal furrows towards the beak of the brachial valve. In the last character the species resembles *P. blairi*, but in that species the interruption of the intercostal furrows continues throughout the entire valve, they being essentially absent altogether towards the beak.

Horizon.—Chouteau limestone.

Productus blairi Miller

Plate XIV, Figs. 14-21

1891. *Productus blairi* Miller, Adv. Sheets 17th Rep. Geol. Surv. Ind., p. 79, pl. 13, fig. 16 (not fig. 17).

1892. *Productus blairi* Miller, 17th Rep. Geol. Surv. Ind., p. 689, pl. 13, fig. 16 (not fig. 17).

Description.—Shell of medium size or smaller, wider than long, the hinge-line shorter than the greatest width, the greatest width at about the mid-length. The dimensions of a nearly complete specimen are; length from hinge-line to anterior margin 20 mm., length from umbonal region to anterior margin 22.4 mm., greatest width 25.2 mm., length of hinge-line 21 mm., convexity of pedicle valve +12 mm., depth of visceral cavity between the two valves 10 mm.

Pedicle valve strongly convex in mature specimens, the umbonal region rather broad and moderately produced beyond the hinge-line, the surface arched from the umbonal region to the front, the median portion of the valve rather broadly flattened with the lateral slopes curving more abruptly to the lateral margins, the auriculations of moderate size, rather sharply differentiated and distinctly compressed horizontally; mesial sinus very shallow, rather broad and ill-defined, originating in the umbonal region; beak small, strongly incurved. Surface marked by strong, radiating costæ which are interrupted upon the posterior slope of the valve and to some extent anteriorly, so as to appear as series of elongate nodes; the posterior half of the valve is crossed by strong, concentric, wrinkle-like markings which become more conspicuous towards the cardinal auriculations; fine concentric lines of growth also cover the entire surface of the valve when it is well preserved. Spine bases not conspicuous unless the node-like interrupted portions of the radiating costæ each bore a spine, as is perhaps the case.

Brachial valve gently concave throughout the visceral portion with the auriculations somewhat deflected, anteriorly and laterally the concavity becomes greater as the curvature of the valve comes more nearly in conformity with the margin of the other valve in its produced portion; the mesial portion of the valve sometimes slightly elevated in its anterior half, in a low, obscure, mesial fold. Surface nearly free from radiating markings towards the beak, but marked beyond this clear space by radiating series of elongated pits which are essentially discontinuous, radiating, intercostal furrows; rather strong, concentric, wrinkle-like markings cover the visceral portion of the valve, and finer concentric lines of growth cover the entire surface.

Remarks.—In the original definition of this species Miller referred to two specimens which he illustrated as the types. One of these specimens, the original of the first of the two illustrations, was correctly interpreted as an external impression of the brachial valve, and this one is here selected as the type of the species. The second specimen illustrated, and interpreted as the internal cast of the pedicle valve, is really an external impression of the brachial valve of quite a different species which is here described as *P. sedaliensis.* Miller evidently did not have, and had not seen the true pedicle valve of his species. *P. blairi* differs markedly from other species of the genus in our Mississippian faunas in the marked interruption of the radiating costæ of the pedicle valve, giving the appearance of series of elongate nodes, and in the interruption of the intercostal furrows of the brachial valve, giving the appearance of series of elongated pits. This style of ornamentation strongly suggests a relationship to some of the Upper Devonian species which have been referred to the genus *Productella,* and it is possible that the species should be referred to that genus, but since the presence or absence of hinge-teeth cannot be determined in any of the specimens examined, the species is allowed to remain in the genus *Productus.*

Horizon.—Chouteau limestone.

Productus inflatus McChesney

Plate X, Figs. 1-6

1860. *Productus inflatus* McChesney, Desc. New Foss., p. 40.
1865. *Productus inflatus* McChesney, Ill. New Spec. Foss., pl. 6, figs. 1a-c.
1868. *Productus inflatus* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 27, pl. 6, figs. 1a-c.

Description.—Shell of medium size or larger, usually longer than wide, the greatest width along the hinge-line, the lateral margins a little sinuate, in front of the cardinal extremities, rounding anteriorly into the anterior margin which is a little sinuate in the middle. The dimensions of a rather large pedicle valve which is broader than usual are: length from hinge-line to anterior margin 20.9 mm., length from umbonal region to anterior

margin 28 mm., length of hinge-line 36 mm., width of body of shell at its mid-length 29.3 mm., convexity of pedicle valve 17 mm.

Pedicle valve gibbous, the umbonal region conspicuously protuberant beyond the hinge-line, the beak strongly incurved, the surface curving abruptly to the cardinal margin and a little more gently to the lateral and anterior margins, auriculate at the cardinal extremities, the auriculations not sharply differentiated from the lateral slopes, rather high and arched antero-posteriorly with the curvature a little more abrupt to the cardinal margin; mesial sinus originating in the umbonal region, rather narrow and of moderate depth. Surface of valve marked by rounded, radiating costæ which increase by bifurcation on the posterior slope of the valve, usually continuing across the anterior slope without division, tending to become fainter or nearly obsolete towards the margin, from .5 mm. to 1 mm. apart in front, usually a little less than 1 mm., becoming smaller and more crowded posteriorly and laterally; crossing the radiating costæ upon the posterior slope of the valve are concentric, wrinkle-like markings which give to that surface a semicirculate ornamentation; spine bases apparently absent or very sparsely and irregularly scattered upon the body of the shell, but when the shell is well preserved a row of three or four rather strong spine bases is present near and parallel with the cardinal margin on each side of the beak. Internal characters of the valve not observed.

Brachial valve only imperfectly known, it is moderately concave in its posterior portion, leaving a rather deep visceral cavity between the two valves, becoming more strongly curved anteriorly and laterally and approaching closely the opposite valve. The surface markings are similar to those of the opposite valve.

Remarks.—In its general size and form this species approaches somewhat closely to *P. burlingtonensis*. It may be easily distinguished from that species by its less depressed or more inflated auriculations of the pedicle valve, with the row of spine bases along the cardinal margin, by the narrower and somewhat more sharply defined mesial sinus and by the somewhat finer radiating costæ. The row of spine bases along the cardinal margin is commonly difficult to recognize because of the condition of preservation of the shells, but the inflated auriculations are easily distinguished in almost every example observed.

Horizon.—Chester group, Okaw formation.

Productus mesialis Hall

Plate X, Figs. 7-13; Plate LXXXIII, Figs. 14-17

1858. *Productus mesialis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 636, pl. 19, figs. 2a-e.

1883. *Productus mesialis* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, figs. 9-10.

1892. *Productus mesialis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, figs. 9-10.

Description.—Shell of medium size or smaller, wider than long, the greatest width along the hinge-line. The dimensions of a pedicle valve, one of the co-types, are: length from hinge-line to front margin 20.2 mm., length from umbonal region to front margin 23 mm., width along hinge-line 31 mm., convexity 18 mm.

Pedicle valve gibbous, more abruptly curved or subgeniculate near the middle, the lateral slopes dropping abruptly to the margins, the umbonal region rather broadly pointed and moderately protuberant beyond the hinge-line, towards the cardinal extremities the surface is compressed and extended into auriculations of moderate size which usually extend somewhat beyond the greatest width of the valve anteriorly and are convex antero-posteriorly; mesial sinus originating in the umbonal region, of moderate width, somewhat variable in depth, rounded in the bottom; the beak pointed and incurved. Surface marked by rounded radiating costæ from .5 mm to 1 mm. in width, which commonly increase by bifurcation upon the posterior slope and less frequently or not at all upon the anterior slope, sometimes becoming obsolescent towards the front and lateral margins; the posterior slope marked by concentric, wrinkle-like markings of only moderate strength or rather faint. Spine bases rather sparsely scattered over the anterior and lateral slopes with a row of about four on each side of the beak along the cardinal margin, with sometimes a few additional ones upon the cardinal auriculations.

Brachial valve with a slight concavity towards the beak, beyond which it is nearly flat throughout the visceral region, bending rather abruptly into the produced anterior and lateral margins, the cardinal auriculations only moderately differentiated from the general surface; towards the front of the visceral surface the median portion of the valve is slightly elevated in an obscure median fold which becomes much stronger upon the anterior produced portion of the valve. Surface marked by radiating costæ similar to those of the opposite valve and by concentric, wrinkle-like markings which are commonly rather faint.

Remarks.—This species is especially characterized by the subgenieulate curvature of the pedicle valve, the well defined mesial sinus of the same valve, and by the flattened visceral portion of the brachial valve. In some respects the shell resembles *P. burlingtonensis*, but it is smaller and broader, with less regular curvature of the pedicle valve, and much flatter visceral portion of the brachial valve. The depth of the mesial sinus of the pedicle valve is a somewhat variable character, in some individuals being almost obsolete.

Horizon.—Keokuk limestone.

Productus mesicostalis n. sp.

Plate XI, Figs. 12-16

Description.—Shell of medium size or smaller, broader than long, the hinge-line apparently a little shorter than the greatest width. The dimensions of a somewhat incomplete pedicle valve are: length from hinge-line to anterior margin 16.2 mm., length from umbonal region to anterior margin 17.5 mm., length of hinge-line approximately 18 mm., greatest width of shell 22 mm., convexity of pedicle valve approximately 13 mm.

Pedicle valve strongly convex, the umbonal region only moderately produced beyond the hinge-line, the beak incurved, the surface curving more abruptly to the cardinal margin, the curvature to the lateral and anterior margins about equal, the cardinal auriculations small; mesial sinus originating in the umbonal region, shallow, rather narrow, and ill-defined laterally. Surface of the valve marked by rounded, radiating plications, increasing by bifurcation, and somewhat irregular in size; along the median line is one plication which is notably larger than any of the others and which is bordered on either side by a broader and deeper furrow; on the posterior surface of the valve the radiating markings are crossed by concentric plications which are fainter in the median portion, becoming wrinkle-like towards the cardinal auriculations; spine bases not distinctly shown.

Brachial valve gently concave posteriorly, becoming more abruptly curved anteriorly and antero-laterally, being produced nearly in contact with the anterior and antero-lateral portions of the opposite valve; anteriorly the mesial portion of the valve is raised in a low mesial fold to correspond with the sinus of the opposite valve. Surface of the valve marked by radiating plications similar to those of the opposite valve.

Remarks.—All examples of this species which have come under observation are more or less incomplete, so that many details of the shell are not yet satisfactorily determined, but the species is especially characterized by the conspicuous mesial plication in the shallow sinus of the pedicle valve, and no difficulty has been found in the identification of any specimen.

Horizon.—English River Grit-stone of the Kinderhook.

Productus viminalis White

Plate XI, Figs. 6-11

1858. *Productus setigerus?* var. *keokuk* Hall, Geol. Iowa, vol. 1, pt. 2, p. 639, pl. 19, figs. 4b-e.
1862. *Productus viminalis* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 29.
1883. *Productus semireticulatus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18), 49, fig. 12 (not 11 and 13).

1892. *Productus semireticulatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18. fig. 12 (not 11 and 13).

Description.—Shell large, as long or longer than wide, the greatest width near the mid-length, the hinge-line shorter than the greatest width. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin 38.5 mm., length from umbonal region to front margin 48 mm., greatest width 47 mm., length of hinge-line 35 mm., convexity 29.5 mm.

Pedicle valve gibbons, arched from the umbonal region to the front margin with the posterior curvature a little more abrupt, the umbonal region rather narrow, conspicuonsly protuberant beyond the hinge-line, the mesial portion of the valve broadly flattened from the umbonal region to the front margin, the lateral slopes curving abruptly to the lateral and cardinal margins, the auriculations at the cardinal extremities very small, the lateral and anterior margins slightly flaring; mesial sinus slight, sometimes essentially wanting, shallow, and ill-defined laterally when present; beak pointed, strongly incurved. Surface marked by rounded, radiating costæ about 1 mm. or 1.5 mm. apart upon the anterior slope, usually becoming coarser and more or less coalescent towards the anterior margin, upon the posterior slope the costæ increase frequently by bifurcation, the divisions becoming much less frequent upon the anterior slope; upon the posterior slope concentric, wrinkle-like markings cross the radiating costæ, giving to the valve a semireticulate style of ornamentation, these markings are strongest towards the cardinal margin, usually becoming rather faint across the median portion of the valve; fine but rather strong concentric lines of growth cover the entire surface of the valve when it is not exfoliated. Spine bases are inconspicuous and only sparsely scattered over the anterior slope of the valve, but just inside the small auriculations upon the lateral slopes of the valve, there is a large group of fine, closely crowded spines. The inner surface of the valve towards the anterior and lateral margins, is thickly covered by rather coarse papillæ or tubercles which appear as pits upon the surface of internal casts.

Brachial valve flattened in the visceral region, more concave anteriorly and laterally and becoming moderately produced with the outer margin of the opposite valve; a broad, low, ill-defined mesial fold commonly originates near the center of the valve and continues to the anterior margin. Surface marked by radiating costæ similar to those of the opposite valve, and in its visceral part by concentric, wrinkle-like markings, the concentric lines of growth similar to those of the opposite valve. Spine bases apparently absent upon the specimens observed. Internally the cardinal process is rather small and bifid, projecting posteriorly into the umbonal cavity of the opposite valve, anteriorly from its base a median ridge or

septum extends some distance, its entire length not shown in the only specimen observed.

Remarks.—The example of this species whose dimensions are given above is an undersized specimen, some large shells having an extreme length of 65 mm. or more. The type specimen of the species, from the Burlington limestone, is here illustrated for the first time, but the species also occurs, perhaps even more commonly, in the Keokuk limestone.

The species is characterized by its large size, its small auricular extensions, its somewhat flaring anterior and lateral margins, and especially by the large groups of fine, closely crowded spines which occur on the lateral slopes adjacent to the cardinal extremities.

Horizon.—Burlington and Keokuk limestones.

Productus crawfordsvillensis n. sp.

Plate XII, Figs. 4-7

1892. *Productus magnus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17A, fig. 15 (not *P. magnus* M. & W.)

Description.—Shell above medium size, broader than long, the greatest width along the hinge-line, the anterior margin slightly sinuate, the visceral cavity between the two valves rather shallow. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin 36.6 mm., length from umbonal region to front margin 41.8 mm., width 47 mm., convexity 30 mm.

Pedicle valve strongly convex, the longitudinal curvature subgeniculate a little back of the line between the visceral and produced portions of the valve, the posterior slope gently convex with the umbonal region only moderately protuberant beyond the hinge-line, compressed towards the cardinal extremities, the anterior slope gently convex, the surface dropping abruptly to the lateral margins, the auriculations small and compressed vertically; mesial sinus originating near the middle of the posterior slope, rather narrow, shallow and rounded in the bottom, lying in the middle of a rather broad region which is gently convex on each side of the sinus and drops away rather abruptly into the lateral slopes; the beak small, incurved, but scarcely reaching beyond the hinge-line. Surface marked by rounded, radiating costæ which increase by frequent bifurcations and intercalations upon the posterior slope, dividing less frequently or sometimes anastomosing upon the anterior slope and becoming more or less obsolete towards the front of mature examples, where best developed upon the anterior slope they are usually about 1 mm. apart from center to center; the posterior slope of the valve is well marked by concentric, wrinkle-like markings, giving it a distinctly semireticulate appearance, these markings often being more strongly defined towards the cardinal margin; the entire surface is marked by fine but per-

feetly distinct lines of growth. The spine bases occur in a rather broad band across the entire valve between the cardinal extremities, just in front of the subgeniculate eurvature of the valve, throughout this band rather strong spines occur more or less uniformly at distanees of from 3 to 5 mm., along the cardinal margin a row of from 5 to 8 spine bases occur on each side of the beak, inereasing in size distally and diverging slightly from the cardinal margin, upon the posterior slope a few spine bases are sometimes sparingly scattered but upon the anterior slope they are eommonly absent beyond the band already deseribed.

Braehial valve gently concave throughout the visceral region but curving abruptly into the produeed portion anteriorly and laterally, the auriculations searcely or not at all differentiated from the general surfaee; mesial fold low, narrow and ill-defined, confined almost entirely to the anterior produced portion of the valve. Surface marked by frequently dividing, radiating costæ similar to those of the opposite valve, whieh beeome more or less obsolescent upon the anterior produeed portion of the valve, and by similar, wrinkle-like, eoneentric markings upon the viseeral portion, also throughout by fine eoneentrie lines of growth. Spine bases seem to be laeking upon this valve. Internally the cardinal proeess is rather small and is apparently trifid, extending posteriorly from the eardinal margin into the umbonal cavity of the opposite valve, anteriorly from the base of the eardinal proeess the median ridge extends nearly to the anterior side of the viseeral portion of the valve, the braehial impressions are rather widely separated and extend anteriorly nearly to the edge of the visceral portion of the valve.

Remarks.—This speeies has been variously identified in the past but it is apparently a well charaeterized, undefined speeies. It may be easily recognized by the snbgeniculate eurvature of the pediele valve, with the conspieuous band of strong spines stretching entirely aronnd the valve between the cardinal extremities and just in front of the genieulate bending of the valve, and by the row of spines along the eardinal margin. The anterior produced portion of the valve is proportionally elongate, and the viseeral cavity between the two valves consequently rather shallow, in one speeimen having a width of 38 mm., the depth of the visceral cavity being only 10 mm.

Horizon.—Keokuk (Crawfordsville beds, Indiana).

Productus magnus Meek and Worthen

Plate XV, Figs. 1-8

1861. *Productus magnus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 142.
1863. *Productus Fentonensis* Swallow, Trans. St. Louis Aead. Nat. Sci., vol. 2, p. 93.

1868. *Productus magnus* Meek and Worthen, Geol. Survey Ill., vol. 3, p 528, pl. 20, figs. 7a-e.

1894. *Productus magnus* Keyes, Mo. Geol. Surv., vol. 5, p. 41.

Description.—Shell large, subhemispherical in form, broader than long, the greatest width at or near the hinge-line. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin 60 mm., length from umbonal region to front margin 65 mm., greatest width 73 mm., convexity 43 mm.

Pedicle valve gibbous, arched longitudinally with the curvature usually more abrupt posteriorly, the umbonal region depressed-convex, only a little protuberant beyond the hinge-line, the lateral slopes gently convex, rather broadly sloping from the central portion of the valve to the lateral margins, the auriculations at the cardinal extremities only slightly differentiated from the general curvature of the lateral slopes; mesial sinus shallow, rather narrow, rounded in the bottom, sometimes almost obsolete; beak small and strongly incurved. Surface covered with somewhat obscure, depressed, rounded, radiating costæ which are rather slender for the size of the shell, usually about 1 mm. from center to center towards the front of the valve, they continue to increase, usually by bifurcation through the entire length of the valve; more or less indistinct, wrinkle-like, concentric markings occur upon the posterior slope of the valve, and concentric lines of growth are present over the entire surface. Rather obscure spine bases are sparsely scattered over the shell surface towards the anterior and lateral margins, and a group of stronger and more conspicuous ones occur near the cardinal margin, these cardinal spines grow larger towards the cardinal extremities and are sometimes arranged in a series of three or four oblique rows with from two to five spines in each row. Interiorly the muscular scars are rather strongly developed and the entire inner surface is roughened by rather fine pits, the anterior and lateral margins which are in contact with the produced portion of the opposite valve being smoother and rather sharply differentiated from the visceral portion.

Brachial valve flattened towards the beak and only gently concave through the entire visceral region, curving more strongly towards the anterior and lateral margins but not geniculate, the auricular portions towards the cardinal extremities not differentiated from the general surface; the mesial portion of the valve, in its anterior half, slightly elevated in a low and narrow fold. Surface of the valve marked by radiating costæ and concentric markings similar to those of the opposite valve. Internally the large and strong cardinal process is bifid at its extremity, anteriorly from its base a low, ridge-like septum extends for three-fourths or more of the length of the valve, and a cardinal ridge extends laterally from each side of the base of the cardinal process nearly parallel with the cardinal margin; the brachial impressions are often distinctly visible

and lie anterior to the middle of the valve; subparallel with the anterior and lateral margins a rugose ridge formed by the thickening of the inner surface of the valve differentiates the visceral portions from the portion which is produced in contact with the opposite valve.

Remarks.—This is one of the largest of our species of *Productus* and is readily distinguished from any other here described by its subhemispherical form, its slightly protuberant umbo of the pedicle valve, its broadly sloping lateral slopes and its slightly differentiated auriculations. The arrangement of spine bases in oblique rows along the cardinal margin, as described, has been clearly observed in several examples, in all the specimens studied in which the preservation is sufficiently good to exhibit the character of these spines, and it is not unlikely that this arrangement is characteristic of the species. The shell described by Swallow as *P. fentonensis* is clearly identical with *P. magnus,* although no examples from Fenton, Missouri, have been seen which are as large as the larger examples of *P. magnus* from Monroe County, Illinois, the type locality for the species.

Horizon.—Upper Keokuk limestone.

Productus tenuicostus Hall

Plate X, Figs. 25-27; Plate XI, Figs. 1-5

1858. *Productus tenuicostus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 675, pl. 24, figs. 2a-d.
1883. *Productus tenuicostus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, fig. 18.
1892. *Productus tenuicostatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 18.
1894. *Productus tenuicostus* Keyes, Mo. Geol. Surv., vol. 5, p. 44.

Description.—Shell thin, of medium size, length and width subequal or longer than wide, the hinge-line shorter than the greatest width. The dimensions of an incomplete pedicle valve are: length from hinge-line to front margin ±25 mm., length from umbonal region to front margin ±31 mm., greatest width ±28 mm., length of hinge-line ±24 mm., convexity ±14 mm.

Pedicle valve gibbous, the greatest convexity posterior to the middle, the umbonal region broad and protuberant beyond the hinge-line, the surface gently convex transversely or slightly sinuate in the median region for about one-half the total width of the valve, the lateral slopes curving abruptly to the lateral margins and usually a little inflected to the cardinal margin, the anterior slope with a much more gentle curvature, the valve sometimes flaring slightly towards the lateral and anterior margins, towards the cardinal extremities the valve is compressed somewhat abruptly to form rather prominent auriculations. Surface marked by fine, more or less irregular, rounded, radiating costæ usually about one-

half millimeter apart, which increase somewhat regularly by bifurcation and intercalation upon the posterior slope, often becoming more or less wavy or flexuose upon the anterior and antero-lateral slopes and increasing irregularly by intercalation or bifurcation, or sometimes anastomosing; upon the posterior slope of the valve there are rather regular, concentric, wrinkle-like markings which vary in strength upon different individuals and usually become stronger towards the cardinal margins; fine concentric lines of growth cover the entire surface when it is perfectly preserved; spine bases rare or wholly absent upon the body of the valve, but indications of a small group of spines of moderate size are frequently present upon the auriculations near the cardinal margin.

Brachial valve not observed.

Remarks.—This species is characterized by the fine radiating costæ and by the thinness of the shell substance. To this last character may be due the irregular and more or less flexuous growth of the costæ upon the anterior and lateral slopes of the valve because of its special liability to injury during growth. The flaring of the pedicle valve towards its outer margin, which is sometimes present, is perhaps due to deformation of the shell during fossilization, again because of its delicacy. In some respects the members of this species resemble *P. ovatus,* but its relationship is rather with the *semireticulatus* type of the genus than with the *cora* type, because of the much more continuous, concentric, wrinkle-like markings of the posterior slope of the shell. The shell resembles *P. ovatus* in its delicacy and in its fine, more or less flexuous costæ, but in that species and its allies the cross wrinkles are confined closely to that portion of the valve adjacent to the cardinal extremities.

Horizon.—St. Louis limestone.

Productus scitulus Meek and Worthen

Plate XIII, Figs. 24-29

1860. *Productus scitulus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 451.

1866 *Productus scitulus* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 280, pl. 20, figs. 5a-d.

Description.—Shell small, usually broader than long but becoming a little longer than wide in old individuals, the hinge-line about equaling the greatest width of the shell, the anterior margin regularly rounded. The dimensions of a large and old example are: length from hinge-line to front margin 9.3 mm., length from umbonal region to front margin 13.5 mm., greatest width 13 mm., convexity of pedicle valve 8.1 mm.

Pedicle valve gibbous, arched from the umbonal region to the front with the posterior curvature shorter and a little more abrupt than the anterior, the umbonal region strongly protuberant beyond the hinge-line,

the median portion of the valve gently convex transversely, curving more strongly into the lateral slopes which drop more or less abruptly to the lateral margins, auriculations at the cardinal extremities rather sharply differentiated, of moderate size, rather strongly convex antero-posteriorly; the median sinus usually obsolete, but in occasional examples a slight median depression occurs; the beak strongly incurved. Surface of the valve marked by fine, radiating costæ, about three of which occupy the space of 1 mm., they increase by bifurcation and intercalation on the posterior slope of the valve but continue with few or no divisions across the anterior slope, on occasional examples several groups of two or three costæ are raised slightly above the general surface upon the anterior slope; crossing the radiating costæ upon the posterior slope are more or less well-defined, concentric, wrinkle-like markings which are commonly stronger toward the cardinal margin; when the surface is not exfoliated, minute, concentric lines of growth are present. Spine bases are commonly inconspicuous, but a few rather widely scattered ones are sometimes present, usually upon the anterior slope.

Brachial valve not observed.

Remarks.—This species is a common one in the St. Louis limestone and may be easily recognized by its small size and its fine, radiating costæ.

Horizon.—St. Louis limestone.

Productus parvus Meek and Worthen

Plate XVI, Figs. 16-22

1860. *Productus parvus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 450.
1866. *Productus parvus* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 297, pl. 23, figs. 4a-c.
1888. *Productus parvus* Herrick, Bull. Sci. Lab. Denison Univ., vol. 4, pl. 11, fig. 11.

Description.—Shell small, length and width usually nearly equal, the greatest width near the mid-length of the shell, the hinge-line about equaling the greatest width. The dimensions of a nearly perfect specimen are: length from umbonal region to front margin 14 mm., length from hinge-line to front margin 10.5 mm., greatest width 14.8 mm., length of hinge-line 14 mm., convexity of pedicle valve 8.5 mm., depth of visceral cavity between the two valves 5.2 mm.

Pedicle valve gibbous, the umbonal region broad and conspicuously protuberant beyond the hinge-line, mesial portion of the valve from the umbonal region to the front broadly flattened or gently convex transversely, the surface of the valve arched from the umbonal region to the front margin with the top of the arch usually situated posterior to the middle, the lateral slopes curving abruptly to the margins, the auricula-

tions at the cardinal extremities rather small and somewhat inflated; the beak strongly incurved beyond the hinge-line; the mesial sinus absent or very slightly developed. Surface of the valve marked by fine, rounded, radiating costæ, about four of which occupy the space of two millimeters towards the front of the shell, posteriorly the costæ increase by bifurcation, but beyond the middle of the valve they continue to the front margin either with none or with infrequent divisions; crossing the radiating costæ on the posterior portion of the valve there are rather inconspicuous, wrinkle-like, concentric markings which are strongest near the auriculations; the entire surface also marked by extremely fine concentric lines of growth which are often obliterated by exfoliation of the surface. Spine bases scattered more or less sparsely over the surface of the valve with a regularly arranged row usually or always present upon each side of the beak, starting close to the hinge-line and describing a curve around the base of the auriculation to the lateral margin a short distance in front of the cardinal extremity, the spines continuously becoming stronger distally. Internal characters not observed.

Brachial valve deeply and rather regularly concave, produced anteriorly and laterally nearly in contact with the opposite valve, the auricular portions at the cardinal extremities somewhat differentiated from the general surface. Surface marked by radiating costæ similar to those of the opposite valve and also by concentric markings; spine bases apparently infrequent or absent. Internal characters not observed.

Remarks.—This species is characterized by its small size, its broad umbonal region, and by the arrangement of the spine bases in a row around the bases of the auricular extension of the pedicle valve. The typical form of the species occurs in the Chester, but a form from the Pella beds of Iowa has also been referred here, which shows some variation from the typical form. In size, general form and proportions the two shells are essentially alike except that some of the Pella specimens are a little larger. The chief difference lies in the greater number of spine bases upon the Pella examples over the entire surface of the pedicle valve, and in the crowding of a group of them upon the auriculations outside of the row which encircles the auriculation.

Horizon.—Ste. Genevieve limestone and Chester group.

Productus setigerus Hall

Plate XII, Figs. 1-3

1858. *Productus setigerus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 638, pl. 19, fig. 3.

1883. *Productus semireticulatus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, fig. 13 (not figs. 11 and 12).

1892. *Productus semireticulatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 13 (not figs. 11 and 12).

Description.—Shell above medium size, about as long as wide, the hinge-line about equaling the greatest width. The dimensions of the holotype, a crushed example showing only the brachial valve with the umbonal region of the pedicle valve, are: length of brachial valve 30 mm., length of pedicle valve 40 mm., greatest width 40 mm. The dimensions of a somewhat distorted pedicle valve are: length from front to hinge-line 28 mm., length from front to greatest extension of umbo 34.3 mm., greatest width 37 mm., convexity 15 mm.

Pedicle valve gibbous, the anterior slope apparently somewhat more abrupt than the posterior, the umbonal region narrow and strongly protuberant posteriorly, the mesial portion of the valve broadly flattened, the lateral slopes curving abruptly to the margins, the cardinal auriculations large, flattened, and rather abruptly differentiated from the lateral slopes; mesial sinus shallow, rather narrow, and ill-defined laterally; beak pointed and strongly incurved. Surface marked by rounded, radiating costæ, usually a little less than 1 mm. from center to center, increasing at intervals by bifurcation; upon the postero-lateral slopes and extending across the cardinal auriculations, rather strong, concentric wrinkles cross the radiating costæ; very fine concentric lines of growth mark the entire surface of the valve when it is perfectly preserved. Spine bases are scattered rather generally over the surface of the valve, especially over the median and anterior regions, usually being placed at intervals of from 5 to 10 mm. apart upon the radiating costæ, and becoming somewhat more numerous upon the lateral slopes towards the cardinal extremities.

Brachial valve apparently gently concave or somewhat flattened in the visceral region, and curving abruptly towards the anterior and lateral margins into the produced portion of the valve; the cardinal auriculations rather sharply differentiated from the general surface of the valve. Surface marked by radiating costæ similar to those of the opposite valve, and also by similar, fine concentric markings; the concentric wrinkles of the shell are less conspicuous than upon the pedicle valve; scattered spine bases occur about as in the opposite valve, increasing in number upon the cardinal auriculations.

Remarks.—This species is evidently a rather thin-shelled form, since the specimens observed are usually more or less distorted. The species has not been commonly recognized since its original definition, and has often been considered as a synonym of *P. semireticulatus*. The holotype of the species is a crushed example upon a limestone slab, the brachial valve and the umbonal region only of the pedicle valve being exposed; extending diagonally outward from each side of the beak is a crowded

group of rather delicate spines which originate from the cardinal auriculations of the pedicle valve and attain an extreme length of about 30 mm. The specimen described by Hall as *P. setigerus* var. *keokuk* is a good example of *P. viminalis* White, from which *P. setigerus* differs in its smaller size, its finer costæ, its proportionally more elongate hinge-line, and the larger cardinal auriculations. In some respects, especially in its relatively fine costæ, *P. setigerus* suggests *P. altonensis* of the Salem limestone, but it is larger than that species with relatively larger cardinal auriculations and possesses a slight median sinus in the pedicle valve.

Horizon.—Keokuk limestone.

Productus altonensis Norwood and Pratten

Plate X, Figs. 14-24

1855. *Productus altonensis* Norwood and Pratten, Jour. Phil. Acad. Sci. (2), vol. 3, p. 7, pl. 1, figs. 1a-c.
1894. *Productus altonensis* Keyes, Mo. Geol. Surv., vol. 5, p. 43.
1906. *Productus burlingtonensis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1301, pl. 17A, figs. 1-1e.
1906. *Productus gallatinensis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1302, pl. 17A, figs. 2-2a.

Description.—Shell a little below medium size, usually a little wider than long, the greatest width about the mid-length of the shell, the hinge-line nearly or quite equaling the greatest width. The dimensions of a pedicle valve are: length from hinge-line to front margin 18 mm., length from umbonal region to front margin 22.5 mm., width 24.2 mm., length of hinge-line ±24 mm., convexity 16 mm.

Pedicle valve gibbous, the umbonal region conspicuously protuberant beyond the hinge-line, its sides converging rather rapidly towards the beak, the angle of convergence often being less than 90 degrees, the surface dropping abruptly to the cardinal margin, nearly regularly arched from the umbonal region to the front margin, curving abruptly to the lateral margins, compressed towards the cardinal extremities in flattened auriculations of moderate size; mesial portion of the valve broadly flattened with the flattened region illdefined laterally, mesial sinus commonly obsolete, when present it is very slight; beak pointed and strongly incurved. Surface of the valve marked by rather fine radiating plications which are subangular posteriorly, becoming more rounded anteriorly, from three to four usually occupy the space of 2 mm. in front, in the posterior portion of the valve the costæ increase frequently by bifurcation, but anteriorly they continue with few or no divisions to the front margin; upon the lateral slopes of the valve, adjacent to and upon the auriculations, conspicuous, wrinkle-like, concentric markings

are developed which are either obsolete across the mesial portion of the valve or are much reduced in strength; the entire surface of the valve marked by very fine, but well-defined concentric markings; when partially exfoliated the shell substance is seen to be rather coarsely but closely punctate, the punctations being more closely crowded upon the summits of the costæ than in the intercostal furrows; spine bases apparently absent or very sparsely present upon the main portion of the valve, becoming more abundant towards the anterior and lateral margins, with a rather closely crowded group upon each auriculation. Internal characters not observed.

Brachial valve concave throughout, produced anteriorly nearly in contact with the opposite valve, the auriculations at the cardinal extremities distinctly differentiated, the visceral cavity between the two valves rather deep. Surface marked by radiating costæ similar to those of the opposite valve but somewhat finer, and by concentric, wrinkle-like markings which are somewhat finer but more uniformly developed than those upon the posterior portion of the opposite valve; the fine concentric markings similar to those of the opposite valve. Spine bases confined chiefly to the auriculations and along the hinge-line, sparsely scattered or apparently absent from other portions of the valve.

Remarks.—This species has not been generally recognized since its original definition by Norwood and Pratten, probably because of the very unsatisfactory illustration of the species which was published by those authors. The shell is a common one in the Salem limestone and has been identified as *P. burlingtonensis* and *P. gallatinensis* by Beede. The species differs from *P. burlingtonensis* in its smaller size, its finer costæ, the more pointed umbonal region, the obsolescent character of the concentric wrinkle-like markings upon the median portion of the posterior part of the pedicle valve, and in the absence of a median sinus in the pedicle valve. In the strong, concentric, wrinkle-like markings of the shell upon and adjacent to the auriculations and their nearly or complete absence across the median portion of the pedicle valve, the species resembles *P. ovatus*, but the radiating costæ are much stronger than in that species and they lack the wavy direction. The punctate character of the shell in this species, which is frequently shown in partially exfoliated specimens, has not been observed in any other species here described.

Horizon.—Salem limestone.

Productus wortheni Hall

Plate XIII, Figs. 13-17

1858. *Productus worthcni* Hall, Geol. Iowa, vol. 1, pt. 2, p. 635, pl. 19, figs. 1a-b.

Description.—Shell of medium size or smaller, usually broader than long, the hinge-line about equaling the greatest width. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin 19 mm., length from umbonal region to front margin 21.4 mm., width 24 mm., convexity 15.5 mm.

Pedicle valve gibbous, the umbonal region prominent and protuberant beyond the hinge-line, the surface curving abruptly towards the margins, depressed at the cardinal extremities to form flattened auriculations of moderate size, along the lateral and anterior margins a slight, inflated, ring-like border is developed; beak pointed and slightly incurved; mesial sinus obsolete, although the mesial portion of the valve is sometimes distinctly flattened. Surface marked by rather fine, rounded or subangular, radiating costæ which increase usually by bifurcation on the posterior portion of the valve, and usually continue across the anterior slope without further division, becoming more or less discontinuous upon the slightly inflated marginal border; about three costæ occupy the space of two millimeters in front, becoming finer towards the cardinal extremities; the posterior portion of the valve is crossed also by more or less inconspicuous, wrinkle-like, concentric markings which become stronger towards the cardinal extremities; spine bases occur rather sparsely scattered upon the anterior slope of the valve, becoming more crowded and finer upon the marginal border, a group of rather closely crowded spine bases also occupies the greater portion of the surface of the auriculations. Internal characters of the valve not observed.

Brachial valve nearly flat through the greater portion of its area, becoming abruptly deflected near the lateral and anterior margins and continuing in contact with the opposite valve, the flattened portion of the valve is a little concave at the beak with a rather broad and low ill-defined elevation extending obliquely from each side of the beak towards the lateral margins, outside of which the auriculations are not sharply differentiated. Surface of the valve marked by radiating costæ similar to those of the opposite valve, and by concentric, wrinkle-like markings which are more conspicuous than those of the opposite valve; spine bases are rare upon the greater portion of the surface, but become abundant upon the deflected marginal border and upon the auriculations. Internally the cardinal process extends posteriorly from the hinge-line into the umbonal cavity of the opposite valve; anteriorly from the base

of the cardinal process a low median ridge or septum reaches beyond the middle of the valve.

Remarks.—This species has its nearest ally in *P. marginicinctus* but it differs markedly from that species in the much less development of the inflated, marginal border of the pedicle valve, in the finer radiating costæ and the less conspicuous concentric, wrinkle-like markings of the posterior portion of the shell, and in the absence of a median sinus of the pedicle valve. The brachial valves are more nearly alike, both being nearly flat throughout most of their width and length, with the abruptly deflected lateral and anterior margins, but the surface markings of the valve in *P. wortheni* are somewhat finer than in *P. marginicinctus*.

Horizon.—Keokuk limestone.

Productus marginicinctus Prout

Plate XIII, Figs. 18-23

1857. *Productus marginicinctus* Prout, Trans. St. Louis Acad. Sci., vol. 1, p. 43, pl. 2, figs. 1-16.
1858. *Productus marginicinctus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, figs. 3a-d.
1894. *Productus marginicinctus* Keyes, Mo. Geol. Surv., vol. 5, p. 43.

Description.—Shell below medium size, usually broader than long, the hinge-line shorter than the greatest width, the greatest width anterior to the mid-length of the shell. The dimensions of a specimen of average size are: length from hinge-line to anterior margin 19.3 mm., length from umbonal region to anterior margin 22 mm., width 24.5 mm., convexity of pedicle valve 15 mm., length of hinge-line ±18 mm.

Pedicle valve gibbous, the umbo prominent and protuberant beyond the hinge-line, the surface curving abruptly towards the margins, compressed towards the cardinal extremities in small auriculations, laterally and anteriorly the surface is abruptly deflected near the margin and then convexly curved and again inflected to form a conspicuous, ring-like or enrolled border; mesial sinus shallow and ill-defined, sometimes nearly or quite obsolete; beak rather small and pointed, incurved. Surface of the valve marked by rather strong, rounded costæ, which increase by bifurcation and intercalation, and which continue with only slight interruption across the ring-like marginal border; on the anterior portion of adult specimens just back of the marginal border the costæ are usually about one millimeter apart from center to center, the distances varying, however, from .5 to 1.5 mm., posteriorly and towards the cardinal extremities the costæ are finer; at more or less irregular intervals the costæ are distinctly nodose, and from each node a slender, elongate spine is produced anteriorly, tangential to the surface, the spines becoming more numerous upon the marginal border; crossing

the radiating costæ in the posterior half of the shell, there are distinct, rounded, wrinkle-like concentric markings, which are stronger towards the cardinal extremities, and the entire surface is covered by exceedingly fine, concentric markings, which are stronger in the intercostal furrows.

Brachial valve nearly flat throughout the greater portion of its area, but curving rather abruptly towards the lateral and anterior margins and continuing for a short distance nearly in contact with the inner surface of the opposite valve; the flattened portion of the valve is gently concave towards the beak, with a rather broad, slightly elevated region extending obliquely from each side of the beak to the lateral margins a little in front of the cardinal extremities, the auriculations flattened. Surface of the valve marked by rounded, radiating costæ somewhat more depressed than those of the opposite valve, which increase by bifurcation and intercalation; the costæ are crossed by finer, concentric, wrinkle-like markings which give to nearly the entire surface a semireticulate appearance, and also by much finer concentric markings similar to those of the opposite valve; at the intersection of the stronger radiating and concentric markings, especially towards the anterior margin of the valve, are slight nodes which are apparently the bases of spines.

Remarks.—This is one of the most distinct species of the genus *Productus* in our faunas, and may be recognized always by the very conspicuous, ring-like inflation about the lateral and anterior margins of the pedicle valve. The only other species among those here recognized possessing a character at all similar to this one, is *P. wortheni*, but in *P. marginicinctus* the feature is very much more conspicuously developed. Both these species are peculiar in the form of the brachial valve, which is so nearly flat throughout the greater portion of its surface with the rather abrupt geniculation near the lateral and anterior margins.

Horizon.—St. Louis limestone.

Productus parvulus Winchell

Plate XIV, Figs. 24-25

1863. *Producta parvula* Winchell, Proc. Acad. Nat. Sci. Phil., p. 4.
1901. *Productus parvulus* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 160, pl. 14, figs. 21-22.

Description.—Shell very small, longer than wide, the hinge-line equaling or a little shorter than the greatest width. The dimensions of two specimens, co-types, are: length from hinge-line to front margin 8 mm. and 6 mm., length from umbonal region to front margin 9.1 mm. and 6.9 mm., greatest width 8.4 mm. and 6.3 mm., length of hinge-line 8 mm. and 6.3 mm., convexity 5 mm. and 3 mm.

Pedicle valve strongly convex, the umbonal region rather narrow and conspicuously protuberant beyond the hinge-line, the surface curving abruptly to the cardinal margin, compressed towards the cardinal extremities to form small but distinct auriculations, to the lateral and anterior margins the curvature is more gentle; mesial sinus absent; the beak small, pointed and strongly incurved. Surface of the valve marked by fine, regular, rounded costæ, from two to three of which occupy the space of one millimeter, all concentric markings inconspicuous or wanting.

Brachial valve not seen.

Remarks.—The specimens which have been used for the basis of the above description are Winchell's co-types from the upper yellow sandstone of the Kinderhook at Burlington, Iowa. The specimens are in the condition of internal casts and do not preserve the markings of the posterior portion of the shell. In the lower beds of the Burlington limestone a small species of *Productus* occurs not infrequently, which is believed to represent this same species, although it grows somewhat larger than the types, often attaining a length of 12 mm. or more. These specimens exhibit the surface markings better than the types, and the rounded costæ are seen to become nearly or quite obsolete before they reach the apex of the beak, they increase by bifurcation at intervals and bear the bases of spines which exhibit the tendency to be arranged in more or less definite rows. Distinct concentric wrinkles are absent but more or less regular lines of growth are present, in addition to which there are exceedingly fine concentric striæ. The impressions of the brachial valve of the Burlington specimens are similar in general form to the pedicle valve except that they are much less convex, and the apical portion of the impression is only slightly protuberant beyond the hinge-line. The essential characters of the species seem to be the small size, the absence of a median sinus or fold, the small auriculations, and the nature of the surface markings.

Horizon.—Upper Kinderhook and lower Burlington limestone.

Productus sampsoni Weller

Plate XIII, Figs. 30-35

1909. *Productus sampsoni* Weller, Bull. Geol. Soc. Am., vol. 20, p. 300, pl. 12, figs. 18-22.

Description.—Shell small, usually longer than wide, regularly rounded or somewhat pointed in front, the hinge-line shorter than the greatest width, the cardinal extremities subangular or a little rounded. The dimensions of a nearly perfect specimen are: length from hinge-line to front margin 8 mm., length from umbonal region of pedicle valve to front

margin 10 mm., greatest width 9 mm., length of hinge-line 7.5 mm., convexity of pedicle valve 4.5 mm., depth of visceral cavity between the two valves 1.6 mm.

Pedicle valve strongly convex with the umbonal region prominent and projecting notably beyond the hinge-line, arched longitudinally with the posterior curvature a little shorter and more abrupt than the anterior, the lateral slopes curving more or less gently from the rather narrowly rounded median portion of the valve to the lateral margins, the surface curving abruptly to the cardinal margin, cardinal auriculations small and inconspicuous or obsolete; mesial sinus obsolete; beak small, pointed, and strongly incurved beyond the hinge-line. Surface of the valve marked by depressed, rounded, radiating costæ which are broader than the intercostal furrows, from one and one-half to three of which occupy the space of one millimeter, the costæ increase by bifurcation throughout the entire length of the valve but the divisions are more frequent posteriorly; crossing the radiating costæ are more or less irregular, appressed, concentric laminæ which in some conditions of preservation of the shell are very conspicuous. Spine bases few and inconspicuous, sometimes apparently obsolete, when present they are usually confined to about two or three upon each side of the beak arranged in an oblique row from the hinge-line on each side of the beak towards a point on the lateral margin in front of the cardinal extremity.

Brachial valve deeply concave, closely following the curvature of the pedicle valve, not differentiated into a visceral and a produced portion, the surface slightly deflected towards the cardinal extremities. Surface marked by radiating costæ similar to those of the opposite valve, and also by similar concentric laminæ.

Remarks.—This small species is entirely different from any other member of the genus in our faunas. It resembles in a somewhat remote degree the *Productella halliana* of the Lime Creek Devonian fauna of Iowa, but it is commonly a narrower shell, more prominent along the median line of the pedicle valve and with similar markings upon the two valves.

Horizon.—Chouteau limestone, and Fern Glen formation.

Productus curtirostris Winchell

Plate XIV, Figs. 8-13

1865. *Producta curtirostra* Winchell, Proc. Acad. Nat. Sci. Phil., p. 114.
1900. *Productus semireticulatus* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 70, pl. 1, figs. 7-8.

Description.—Shell semielliptical or subsemielliptical in outline, of about medium size or a little larger, length and breadth subequal, the hinge-line equal to or a little shorter than the greatest width. The dimensions of two nearly complete pedicle valves, co-types, are: length from hinge-line to anterior margin 24.5 mm. and 25.2 mm., length from umbonal re-

gion to front margin 25 mm. and 25.8 mm., greatest width 30.8 mm. and 27.7 mm., length of hinge-line 26 mm. and 26 mm., convexity 10 mm. and 9 mm.

Pedicle valve convex with the greatest depth posterior to the middle, the umbonal region very slightly protuberant beyond the hinge-line, the surface of the valve curving rather abruptly to the cardinal margin, with the curvature only slightly modified towards the cardinal extremities because of the almost obsolete cardinal auriculations, to the lateral and anterior margins the curvature is more gentle; mesial sinus entirely wanting; the beak very short and obtuse, scarcely differentiated from the umbonal surface and not extended beyond the cardinal margin. Surface of the valve marked by low, rounded, moderately fine, more or less discontinuous, longitudinal costæ, and by a few more or less inconspicuous concentric wrinkles posteriorly, which are strongest towards the cardinal extremities.

Brachial valve concave, the curvature following that of the pedicle valve with a rather thin visceral cavity, with no mesial fold or sinus. The surface markings entirely similar to those of the opposite valve.

Remarks.—This species is especially characterized by the flattened umbonal region, the almost obsolete beak, and the slight posterior protuberance of the umbo. In its general aspect the form of the pedicle valve suggests an impression of the concave brachial valve of some species of *Productus*, and for a time the species was so interpreted. A sufficient number of examples having both valves in place have been observed, however, to make it certain that such an interpretation is an incorrect one, and that Winchell was right in his interpretation of the species. The discontinuity of the radiating markings of the shell, together with the low convexity of the pedicle valve, are somewhat suggestive of the genus *Productella*, but until the generic characters can be more definitely determined the species may be allowed to remain in *Productus* where it was originally placed by Winchell.

Horizon.—Chonopectus sandstone of the Kinderhook.

Productus indianensis Hall

Plate XVIII, Figs. 7-10; Plate LXXXIII, Figs. 12-13

1856. *Productus Indianensis* Hall, Trans. Albany Inst., vol. 1, p. 47.
1882. *Productus Indianensis* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 47, pl. 6, figs. 6-7.
1883. *Productus Indianensis* Hall, 12th Rep. Geol. Surv. Ind., p. 326, pl. 29, figs. 6-7.
1906. *Productus indianensis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1300, pl. 19, figs. 7-7a; pl. 22, figs. 6-7.

Description.—Shell very small, longer than wide, the hinge-line a little shorter than the greatest width, the greatest width near the mid-length

The dimensions of two nearly complete pedicle valves, the first of which is one of the co-types, are: length from hinge-line to front margin 6.3 mm. and 5.5 mm., length from umbonal region to front margin 7.2 mm. and 6.5 mm., greatest width 6.9 mm. and 5.5 mm., length of hinge-line 5.6 mm. and 5 mm., convexity 4 mm. and 3.5 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region broad and prominent, strongly protuberant beyond the hinge-line, the surface rather narrowly rounded transversely along the median line of the valve, curving rather abruptly to the lateral margins and more gently to the anterior margin, a little compressed toward the cardinal extremities, the auricular extensions inconspicuous; mesial sinus obsolete; beak strongly incurved and extending beyond the hinge-line. Surface without regular radiating costæ, but marked by fine, concentric lines of growth which are somewhat more prominent at intervals, giving a rather indefinite concentrically banded appearance. Spine bases of moderate size with a tendency to be arranged in somewhat irregular concentric rows.

Brachial valve not observed.

Remarks.—The original illustrations of this species suggest a shell similar to *P. biseriatus,* but in fact the two species are entirely different. *P. indianensis* is much smaller than *P. biseriatus,* narrower, more strongly convex, and with a much more prominent umbonal region in the pedicle valve. The surface markings of the two shells are also very different, the spines of *P. indianensis* are apparently not the fine, closely appressed spines of *P. biseriatus* and *P. punctatus,* but are more erect, and the shell does not exhibit the distinctly banded markings of *P. biseriatus.* The style of ornamentation with the absence of radiating costæ and somewhat indefinitely arranged spine bases suggests some of the shells from the Devonian and lower Mississippian faunas which have usually been referred to the genus *Productella,* and it is possible that this species should be so referred.

Horizon.—Salem limestone.

Productus ovatus Hall

Plate XVI, Figs. 1-15

1858. *Productus ovatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1.
1859. *Productus pilciformis* McChesney, Desc. New Pal. Foss., p. 40.
1860. *Productus lævicostus* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 230.
1863. *Productus coræformis* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 94.
1874. *Productus prattenianus* (= ? *P. lævicostus*) White, Prelim. Rep. Inv. Foss., p. 17.
1877. *Productus prattenianus* (pars.) White, U. S. Geog. Surveys W. 100th Mer., vol. 4, p. 113.

1877. *Productus lævicostus ?* Hall and Whitfield, U. S. Geol. Expl. 40th Par., vol. 4, p. 266, pl. 5, figs. 7-8.
1883. *Productus ovatus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, fig. 19.
1891. *Productus pileiformis* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 582, pl. 13, figs. 13-14.
1892. *Productus ovatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 19.
1894. *Productus lævicostus* Keyes, Mo. Geol. Surv., vol. 5, p. 41, pl. 38, fig. 1.
1894. *Productus ovatus* Keyes, Mo. Geol. Surv., vol. 5, p. 44.
1895. *Productus pileiformis* Whitfield, Geol. Surv. Ohio, vol. 7, p. 470, pl. 9, figs. 13-14.
1899. *Productus lævicosta* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 534, pl. 69, figs. 9a-e.
1900. *Productus lævicostus* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 71, pl. 1, figs. 1-2.
1903. *Productus lævicostus* Girty, Prof. Paper, U. S. Geol. Survey, No. 16, p. 284.
1909. *Productus pileiformis* Girty, Bull. U. S. Geol. Survey No. 377, p. 26, pl. 2, fig. 7.
1911. *Productus pileiformis* Girty, Bull. U. S. Geol. Survey No. 439, p. 44, pl. 4, figs. 1-2.
1911. *Productus pileiformis* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 370, figs. 8a-c.

Description.—Shell thin and delicate, variable in size but usually of medium size or larger, longer than wide, the hinge-line shorter than the greatest width, the cardinal extremities angular. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin +27.5 mm., length from umbonal region to front margin +34 mm., greatest width 27 mm., length of hinge-line 23.5 mm., convexity 22.5 mm.

Pedicle valve gibbous, the greatest convexity posterior to the middle, the umbonal region prominent and strongly protuberant beyond the hinge-line, the surface arched from the umbonal region to the front with the posterior curvature shorter and somewhat more abrupt, the lateral slopes curving abruptly from the median portion of the valve to the lateral margins, and defleeted as they approach the cardinal extremities to form rather small auriculations; mesial sinus entirely absent; the beak small, pointed, and closely incurved. Surface marked by fine, rounded, radiating, more or less flexuous costæ, on the posterior portion of the valve they are more regular and increase frequently by interealation, the intercalated costæ increasing in size very gradually, anteriorly the intercalated costæ becomes less frequent, the costæ often become more irregular in growth and more flexuous upon the more mature portion of the valve where from two to three costæ usually occupy the spaee of one millimeter; towards the cardinal extremities and extending up on the lateral slopes there are strong and distinct, rounded, transverse wrinkle-

like folds which rarely or never cross the median portion of the valve; the entire surface, when well preserved, marked by exceedingly fine, concentric lines of growth. Spine bases usually inconspicuous, but rather elongate; slender, sparsely scattered spines are present upon some specimens when they occur in a favorable condition of preservation.

Brachial valve deeply concave with the surface compressed towards the cardinal extremities to form small auriculations, the convex external impressions of the valve resemble examples of the pedicle valve except that the umbonal region protrudes beyond the hinge-line either not at all or only slightly. Surface of the valve marked by fine, rounded, more or less flexuous and irregular, radiating costæ, entirely similar to those of the opposite valve; towards the cardinal extremities strong, concentric, wrinkle-like folds, similar to those of the opposite valve, occur, but, unlike those of that valve, at least some of them continue across the median portion of the valve, although much more faintly developed than towards the cardinal extremities; entire surface, when well preserved, covered by fine, concentric, lines of growth.

Remarks.—This species ranges through the Mississippian formations, although it occurs much more abundantly at certain horizons than others. It is a species belonging to the *P. cora* group of the genus, and should perhaps not be considered as distinct from that species. On comparison with the figures of the type specimen of *P. cora*[1] there seems to be no essential features which can be used to distinguish our Mississippian shells, unless it be that the type is less strongly convex transversely. The auriculations are imperfectly preserved in D'Orbigny's type, and do not show in the recent illustration, but in his original figure they are made very large and conspicuous besides being mentioned in his original description, and they may have been destroyed since the original definition of the species was written. These Mississippian shells resemble a common form in the Pennsylvanian faunas which is generally more broadly rounded transversely and has more conspicuous auriculations, agreeing in both these characters with the original *P. cora* with which they are commonly identified, and as the Mississippian and Pennsylvanian forms are quite certainly distinct specifically, D'Orbigny's name is retained for the later form.

Hall described *P. ovatus* in 1858 from a St. Louis limestone specimen preserved in a somewhat weathered condition. The type specimen does not show the hinge-line, but it does show the surface spines more satisfactorily than most examples. In the more recent collections many specimens from the same horizon occur, some in a condition of preservation similar to the type and others showing the entire form of the shell much more satisfactorily, and it is from such examples that the above descrip-

[1] Pal. Universalis, vol. 1, No. 2 (1903).

tion of the species has been largely made. In 1859 McChesney described his *P. pileiformis* from the Chester limestone, and while examples of the species are less common in this horizon than in the St. Louis limestone, a careful examination of all available specimens has not shown a single character by which they can be distinguished. In the final publication of his paper in 1867, McChesney[1] gives no illustration of the species and makes no mention of it, and the supposition is that he himself abandoned it. The specimen figured by Whitfield under this specific name in 1891 and 1895, is an impression of the exterior of the brachial valve and differs in no essential respects from similar specimens of *P. ovatus*. White's species *P. lævicostus* was described in 1860 from a much lower horizon, the Kinderhook, and his type specimens have never been illustrated. Authentic specimens from the typical locality are at hand, however, and no way has been discovered by which they can be distinguished from the specimens from the higher beds. The *P. coræformis* of Swallow has never been illustrated, it has never been recognized since its original definition and was evidently based upon a small example of the common species of our Mississippian faunas.

From a careful examination of all available material it has been impossible to detect means of differentiating more than a single species of *Productus* of the type of *P. cora* in the Mississippian faunas under consideration, and for this species Hall's name, *P. ovatus*, has priority. The species is a variable one, variations in proportional length and breadth, coarseness of costæ, strength of the concentric, wrinkle-like folds, and in the surface spines being common, but in no case have the variations been found to be constant in character.

Horizon.—Kinderhook, Burlington limestone, Keokuk limestone, Salem limestone, St. Louis limestone, Ste. Genevieve limestone, and Chester group.

Genus *DIAPHRAGMUS* Girty

Description.—Shell productoid in form, with the external surface of the valves marked by distinct radial costæ. Internally the hinge characters of both valves resemble *Productus*. The diagnostic character of the genus consists of a partition which is an outgrowth from the inner surface of the brachial valve at its geniculation, continuing in nearly the same plane as the visceral portion of the valve to the inner surface of the pedicle valve. Beyond this partition both valves are notably produced, their inner surfaces being nearly or quite in contact. In the fossil specimens the visceral surface of the brachial valve continued into the partition constitutes a cleavage plane along which the shells are often broken.

[1] Trans. Chicago Acad. Sci., vol. 1 (1867).

Remarks.—Among the productoid genera *Diaphragmus* has its closest relative in *Marginifera*. In *Marginifera*, however, the visceral portion of the brachial valve is surrounded by a ridge-like elevation which rises vertically from the inner surface of the valve instead of continuing in the same plane as is the condition in *Diaphragmus*. *Marginifera* has not as yet been recognized in any of the Mississippian faunas, its earliest appearance being in the Pennsylvanian, while *Diaphragmus* occurs only in the later Mississippian, so far as it is known at present, and is represented by a single species.

Diaphragmus elegans (Norwood and Pratten)

Plate XII, Figs. 8-17

1855. *Productus elegans* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil. (2), vol. 3, p. 3, pl. 1, figs. 7a-c.
1855. *Productus flexistria* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil. (2), vol. 3, p. 6.
1860. *Productus fasciculatus* McChesney, Desc. New Pal. Foss., p. 38.
1860. *Productus Cestriensis* Worthen, Trans. St. Louis Acad. Sci., vol. 1, p. 570.
1877. *Productus elegans* Hall and Whitfield, U. S. Geol. Expl. 40th Par., vol. 4, p. 268, pl. 5, figs. 3, 4.
1891. *Productus elegans* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 581, pl. 13, figs. 15, 16.
1894. *Productus cestriensis* Keyes, Mo. Geol. Surv., vol. 5, p. 44.
1895. *Productus elegans* Whitfield, Geol. Surv. Ohio, vol. 7, p. 669, pl. 9, figs. 15, 16.
1897. *Productus cestriensis* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 256, pl. 18, figs. 7-9.
1909. *Productus fasciculatus* Bassler, Va. Geol. Surv., Bull. No. II A, pl. 29, figs. 12, 13.
1910. *Diaphragmus elegans* Girty, Ann. N. Y. Acad. Sci., vol. 20, p. 217.
1911. *Diaphragmus elegans* Girty, Bull. U. S. Geol. Survey No. 439, p. 51, pl. 4, figs. 4-5
1911. *Productus cestriensis* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 372, figs. 9a-g.

Description.—Shell usually below medium size, longer than wide, the greatest width near the mid-length, the hinge-line shorter than the greatest width. The dimensions of a pedicle valve of about average size are: length from hinge-line to front margin 17 mm., length from umbonal region to front margin 22 mm., greatest width 21.8 mm., length of hinge-line 17 mm., convexity of pedicle valve 14 mm.

Pedicle valve gibbous, the umbonal region protuberant posteriorly beyond the cardinal margin, the surface dropping nearly vertically to the cardinal margins, curving abruptly to the lateral and anterior margins, compressed at the cardinal extremities into rather small, flattened auriculations; mesial portion of the valve usually broadly flattened from the

umbonal region to the anterior margin, the mesial sinus obsolete or very shallow and ill-defined; the beak strongly incurved. Surface of the valve marked by rounded, radiating costæ which increase usually by bifurcation in the posterior portion of the valve, and continue to the front margin with much less frequent divisions, in some specimens becoming more or less fasciculate towards the front, at the front of mature shells the costæ are usually separated about one millimeter or less from center to center, becoming somewhat smaller upon the lateral slopes towards the cardinal extremities; crossing the radiating plications upon the posterior portion of the valve are rather inconspicuous, concentric, wrinkle-like markings which are often nearly obsolete, other exceedingly fine concentric markings cover the entire surface of the valve when it is well preserved; spine bases are rare or nearly obsolete upon the greater portion of the surface of the valve, those present being sparsely scattered, usually towards the front, but upon the auriculations and the lateral slopes just inside the auriculations, is a group of rather fine, crowded spine bases, sometimes forty or more in number.

Brachial valve gently concave or flattened in the visceral region, curving more strongly anteriorly and laterally where the outer margin of the valve is conspicuously produced nearly in contact with the inner surface of the opposite valve, not infrequently the inner portion of the gently concave visceral part of the valve is more or less differentiated, the differentiated region being somewhat more concave and being bounded by a rather strong, concentric line of growth. Surface of the valve marked by radiating costæ similar to those of the opposite valve, often being somewhat better defined posteriorly in the more concave differentiated portion of the valve; ill-defined, concentric, wrinkle-like markings, usually stronger than those of the opposite valve, occupy the visceral portion of the valve and the entire surface is covered by very fine concentric markings similar to those of the opposite valve; spine bases commonly if not always absent. Internally the posterior visceral portion of the valve is sharply differentiated from the anterior and anterolateral produced portion of the valve, by the development of a partition which is apparently a continuation of the gently concave or flattened visceral portion of the valve; not infrequently the specimens break along this partition separating the produced portion of the shell entirely from the visceral portion and giving it quite a different aspect from the entire shell. Other internal characters of the shell not observed.

Remarks.—This species is easily recognized on account of the subquadrangular form of the posterior view of the shell due to the broadly flattened mesial portion of the pedicle valve and the nearly vertical position of the lateral slopes towards the cardinal margin. Other characteristic features of the species are the short hinge-line, the crowded group

of spine bases on and adjacent to the auriculations, and the very peculiar development of the partition from the inner surface of the brachial valve which so completely separates the visceral from the anteriorly produced portion of the valve. The species is usually rather small, but examples with a length of 30 mm. or more are not infrequent in some localities. In most localities the fasciculate arrangement of the costæ is not a conspicuous feature of the species.

Horizon.—Chester group.

Genus *ECHINOCONCHUS* n. gen.

Description.—Shell productoid in form and with internal characters as in the genus *Productus*. The external surface of the valves marked by more or less sharply differentiated concentric bands which commonly grow broader in passing from the beak to the outer margins, each band bearing numerous, crowded, fine, appressed, imbricating spines, either subequal or unequal in size, which are produced from elongate, node-like bases.

Remarks.—This genus is proposed to include those shells which have heretofore been placed in the genus *Productus* in the group typified by *P. punctatus*. This whole group of species differs so fundamentally from the members of the genus *Productus* as typified by the genotype, *P. semireticulatus*, in their surface markings, that it has long seemed to the writer that they should be separated under a different generic name, although their internal characters are essentially alike. The genus is represented in the Mississippian faunas under consideration by several species, none of which suggest any intergradation with those of the restricted *Productus*.

ECHINOCONCHUS ALTERNATUS (Norwood and Pratten)
Plate XVII, Figs. 1-7

1855. *Productus alternatus* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., (2), vol. 3, p. 20, pl. 2, figs. 1a-e.
1858. *Productus vittatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 639.
1863. *Productus gradatus* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 93.
1883. *Productus alternatus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, fig. 14.
1883. *Productus vittatus* Hall, Rep. N. Y. State Geol. for 1882, pl. (18) 49, figs. 15-17.
1892. *Productus alternatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 14.
1892. *Productus vittatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, figs. 15-17.
1894. *Productus vittatus* Keyes, Mo. Geol. Surv., vol. 5, p. 43.

Description.—Shell large, usually as wide or wider than long, but occasionally longer than wide, the hinge-line a little shorter than

the greatest width, the cardinal extremities obtusely angular or a little rounded. The dimensions of a nearly complete example are: length from hinge-line to front margin 42 mm., length from umbonal region to front margin 50 mm., greatest width 49 mm., length of hinge-line ±40 mm., convexity of pedicle valve 25 mm., depth of visceral cavity between the two valves 18 mm.

Pedicle valve strongly convex with the point of greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin, less abruptly to the lateral margins and more gently to the anterior margin, compressed towards the cardinal extremities in subauriculate expansions which are not sharply differentiated from the general surface, the umbonal region prominent and strongly protuberant beyond the cardinal margin; mesial sinus originating in the umbonal region, usually of moderate depth, rather broad, rounded in the bottom and ill defined laterally; the beak strongly incurved. Surface of the valve, in the exfoliated condition, marked by strong, regular, concentric bands which are rather abruptly elevated at their anterior margin with the surface sloping regularly to the line of elevation of the next posterior band, these bands vary in width from 1 to 5 mm., usually being narrower towards the beak and again towards the front margin in mature shells, with the broadest bands in the middle portion of the valve; when the surface is not exfoliated these concentric bands bear closely crowded, fine, appressed spines directed anteriorly, the more posterior rows overlapping those in front, upon each concentric band the coarser spines are along its anterior margin, the more posterior ones being finer, with a narrow, naked area along the posterior border of each band nearly or wholly free from spines.

Brachial valve concave at the beak, the concavity extending anteriorly with broadly diverging, but indefinite lateral borders which intersect the lateral borders of the valve at about mid-length, towards the cardinal extremities the surface is somewhat flattened, the visceral portion not sharply differentiated from the produced part; near or posterior to the middle of the valve, a low, but rather broad, rounded, ill-defined mesial fold originates which grows more prominent anteriorly. Surface marked by concentric bands and fine, appressed spines similar to those of the opposite valve.

Remarks.—It is not clear that this species should be differentiated from *E. punctatus* Martin, but this form having its most typical development in the Keokuk limestone commonly has been considered as distinct from the Pennsylvanian shell usually designated by Martin's name. The Keokuk shell has a proportionally longer hinge-line, a broader umbonal region and more obtusely pointed beak than the Pennsylvanian shell, and the concentric bands of the surface are usually broader and stronger,

with the spine bases smaller and less numerous, although this latter character may be more or less dependent upon the state of preservation. Martin's type specimens of *punctatus* were evidently collected in the "Mountain limestone", a formation equivalent to our Mississippian, and among his original illustrations the larger specimens seem to agree well with the shells from the Keokuk limestone, so that it is possible that his name should be applied to the shells here under consideration and a different name assigned to the Pennsylvanian shells. As to the identity of Norwood and Pratten's *P. alternatus* with Hall's *P. vittatus*, there can be no doubt; the identity of Swallow's *P. gradatus* is less certain, although it is probably a synonym also. Some specimens from the St. Louis limestone have a shorter hinge-line and narrower umbo, approaching more nearly the Pennsylvanian shells, and should perhaps be excluded from this species.

Horizon.—Burlington limestone, Keokuk limestone, ?St. Louis limestone, and ?Okaw formation of the Chester group.

Echinoconchus genevievensis n. sp.

Plate XVIII, Figs. 1-6

Description.—Shell a little above medium size, broader than long, the hinge-line much shorter than the greatest width, the greatest width anterior to the mid-length. The dimensions of a nearly complete pedicle valve are: length from hinge-line to front margin 22.2 mm., length from umbonal region to front margin 27.6 mm., greatest width 31 mm., length of hinge-line 21 mm., convexity 31 mm.

Pedicle valve strongly convex with the greatest depth posterior to the middle, the umbonal region prominent but rather narrow, protuberant posteriorly beyond the hinge-line, the surface curving abruptly to the cardinal margin, curving more gently to the lateral and anterior margins, only slightly compressed towards the cardinal extremities; mesial sinus originating posteriorly in the umbonal region, it is of only moderate width and depth, rounded in the bottom and ill defined laterally; the beak rather small, pointed and strongly incurved. Surface marked by regular, more or less well-defined, concentric bands from two to four millimeters in width, upon which are the elongate bases of fine, crowded, appressed spines, those near the front of each band being finer than those situated posteriorly.

Brachial valve gently concave throughout, except towards the cardinal extremities, which are flattened, near or posterior to the middle of the valve, a low, rounded, mesial fold originates which becomes a little stronger towards the front. The surface marked by concentric bands and appressed spines similar to those of the opposite valve.

Remarks.—This species is much like *E. alternatus* of the Keokuk limestone, but mature examples are always much smaller than in that species, the hinge-line is proportionally shorter, the umbonal region is much narrower and more sharply pointed towards the beak. These characters are apparently constant and the shell is so commonly found in the Ste. Genevieve limestone that it has seemed best to recognize it as a good species, although a broad interpretation of *E. punctatus* might include not only this form but *E. alternatus* as well.

Horizon.—Ste. Genevieve limestone.

Echinoconchus biseriatus (Hall)

Plate XVII, Figs. 10-15

1855. *Productus fimbriatus* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil. (2), vol. 3, p. 19 (not *P. fimbriatus* Sowerby).
1856. *Productus biseriatus* Hall, Trans. Albany Inst., vol. 4, p. 12.
1882. *Productus biseriatus* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, pl. 6, figs. 8-12.
1883. *Productus biseriatus* Hall, 12th Rep. Geol. Surv. Ind., p. 325, pl. 29, figs. 8-12.
1894. *Productus biseriatus* Keyes, Mo. Geol. Surv., vol. 5, p. 43.
1906. *Productus biseriatus* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1299, pl. 19, fig. 6; pl. 22, figs. 8-12.
1911. *Productus biseriatus* Girty, Bull. U. S. Geol. Survey No. 439, p. 46, pl. 3, figs. 10-11.

Description.—Shell small, length and width usually about equal, but varying from longer than wide to wider than long, the hinge-line shorter than the greatest width, the greatest width near or anterior to the mid-length, the cardinal extremities obtusely angular or a little rounded. The dimensions of a nearly perfect specimen are: length from hinge-line to front margin 11.4 mm., length from umbonal region of pedicle valve to front margin 13.7 mm., greatest width 13.5 mm., length of hinge-line 10 mm., convexity of pedicle valve 7 mm., depth of visceral cavity between the two valves 4.4 mm.

Pedicle valve strongly convex, the umbonal region pointed and protuberant beyond the hinge-line, the surface curving abruptly to the cardinal margin, more gently to the lateral and anterior margins, compressed at the cardinal extremities to form small auriculations which are not sharply differentiated from the lateral slopes; mesial sinus obsolete; beak pointed and strongly incurved beyond the hinge-line. Surface marked by regular concentric bands which are differentiated by a slight elevation of the surface along their anterior margin, upon each concentric band is a row of elongate nodes, highest in front, the bases of appressed spines, which become lower posteriorly and disappear in front of the posterior margin of the band; closely crowded between and in front of these larger nodes are numerous finer but entirely similar nodes which

are the bases of finer appressed spines; the spines themselves are commonly destroyed, but they are doubtless entirely similar to those of *P. punctatus.*

Brachial valve concave, the central concavity narrower at the beak and rapidly broadening towards the front, with the surface somewhat flattened and subauriculate towards the cardinal extremities; mesial fold absent. Surface marked by concentric bands similar to those of the opposite valve and with similar appressed spine bases.

Remarks.—This little species is clearly of the type of *E. alternatus,* from which species it differs chiefly in its much smaller size and in the absence of a mesial sinus in the pedicle valve and fold in the brachial valve. One of the largest examples observed has a length of 18 mm.

Horizon.—Salem limestone.

Echinoconchus morbillianus (Winchell)

Plate XVIII, Figs. 13-15

1865. *Productus morbillianus* Winchell, Proc. Acad. Nat. Sci. Phil., p. 113.

Description.—Shell small, a little wider than long, the hinge-line shorter than the greatest width, the greatest width anterior to the mid-length, the cardinal extremities obtusely subangular. The dimensions of a nearly complete pedicle valve, the holotype, are: length from hinge-line to front margin 12 mm., length from umbonal region to front margin 13.8 mm., greatest width 14.5 mm., length of hinge-line 12 mm., convexity 6 mm.

Pedicle valve strongly convex, the greatest depth posterior to the middle, the umbonal region prominent and somewhat protuberant posteriorly beyond the hinge-line, the surface curving abruptly to the cardinal margin on each side of the beak, and much more gently to the lateral and anterior margins, compressed at the cardinal extremities to form small auricular expansions; mesial sinus obsolete; the beak small, pointed and strongly incurved. Surface marked by regular, concentric bands whose width at the median line of the valve is 1 to 1.5 mm., each band is slightly depressed posteriorly below the anterior margin of the band next behind, and each is marked by the radially arranged and nearly uniform elongate bases of fine, appressed spines, higher in front where the spines have become free and becoming obsolete posteriorly at or near the posterior margin of the concentric band; towards the cardinal extremities the regular arrangement of the concentric bands and spine bases becomes somewhat disorganized.

Brachial valve not known.

Remarks.—This little *Echinoconchus* most closely resembles the small *E. biseriatus* of the Salem limestone. These two species are similar in size and in both the mesial sinus is wanting. *E. morbillianus* is perhaps

more narrowly rounded transversely across the median part of the pedicle valve, in consequence of which the lateral slopes curve less abruptly to the lateral margins, but a larger number of examples should be examined to determine this as a constant character. The most essential difference between the two species is in the character of the fine appressed spines which are essentially uniform in size upon *E. morbillianus* with more elongate bases, while in *E. biseriatus* the spine bases occur in two distinct sizes, larger ones posteriorly upon each band with much smaller and more numerous ones closely crowded anteriorly.

A second example of the species is mentioned by Winchell, "a cast from the Yellow Sandstone below (probably No. 5)," as being probably identical. A careful examination of the two specimens, however, clearly indicates that they are not the same species, and furthermore the Yellow Sandstone specimen is probably a *Productella*.

Horizon.—Base of Burlington limestone.

Genus *STROPHALOSIA* King

Description.—Shells resembling *Productus* or *Productella* in general form, with a distinct cicatrix on the umbo of the pedicle valve at the point where they have been attached by the shell substance to some external object, or attached by nearly the entire outer surface of the pedicle valve. Pedicle valve with a well-defined cardinal area, the delthyrium closed by a deltidium, cardinal teeth prominent but not supported by dental lamellæ. Brachial valve with a narrower cardinal area, the cardinal process erect, bifid on its anterior and trifid on its posterior face, supported laterally by the socket plates and continued anteriorly into a median septum which extends half the length of the valve. Surface of the pedicle valve spinose, the spines near the beak often recurved and embracing some external object, and in some species all the spines assisting in the attachment of the shell. Brachial valve either spinose, lamellose, or smooth externally.

Remarks.—Among the species which have been referred to the genus *Strophalosia* in the present report are two rather distinct types. One of these contains small species, such as *S. scintilla* and *S. keokuk*, which are attached to other brachiopod or mollusc shells by essentially the entire outer surface of the pedicle valve, the surface spines being little root-like processes which grow outward from the shell margin in all directions in close attachment throughout their entire length. The other type of shell is larger and was attached during life by the umbonal portion of the pedicle valve only, being represented by the two species *S. cymbula* and *S. beecheri*.

Strophalosia scintilla Beecher

Plate XVIII, Figs. 19-23

1890. *Strophalosia scintilla* Beecher, Am. Jour. Sci. (3), vol. 40, p. 243, pl. 9, figs. 10-13.
1892. *Strophalosia scintilla* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 15B, figs. 32-34.
1908. *Strophalosia scintilla* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 76, pl. 17, figs. 26-29.

Description.—Shell very small, attached to foreign objects by nearly the entire surface of the pedicle valve, wider than long,transversely subelliptical in outline with the posterior margin truncated, the hinge-line a little shorter than the greatest width. The dimensions of a nearly complete example are: length 1.9 mm., width 3.1 mm.

Pedicle valve adherent to foreign objects, usually to shells of other brachiopods, its margin elevated and usually furnished with a variable number of slender, procumbent spines, rarely more than six or seven in number and sometimes wholly wanting, the spines rarely or never occur along the cardinal margin; cardinal area low and broadly triangular, with a small delthyrium closed by a deltidium, the hinge-teeth small, but well developed, unsupported by dental lamellæ.

Brachial valve convex at the beak, becoming flat or concave anteriorly; the beak inconspicuous, scarcely or not at all extended beyond the hinge-line; the surface marked by concentric lines of growth.

Internally the adductor muscular scars are small and the surface is pustulose near the margin; the brachial impressions have not been observed.

Remarks.—This species is the smallest member of the genus so far known in the faunas under consideration. It resembles *S. keokuk* in the almost complete attachment of the pedicle valve to foreign objects, but it differs from that species, in addition to its smaller size, in the smaller number and less crowded attaching spines, and in the apparent absence of these spines along the cardinal margin. This last character seems to be a good one for the species, in no case have the spines been observed growing from the central portion of the cardinal margin, and in only one or two examples have they seemed to be present at one of the outer extremities of this margin, even these not being so well preserved as to make it certain that they are spines.

Horizon.—Louisiana limestone of the Kinderhook.

STROPHALOSIA KEOKUK Beecher

Plate XVIII, Figs. 17-18

1890. *Strophalosia Keokuk* Beecher, Am. Jour. Sci. (3), vol. 40, p. 244, pl. 9, figs. 18-24.
1892. *Strophalosia Keokuk* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17A, figs. 5-7.

Description.—Shell small, attached to external objects by nearly the entire pedicle valve, broader than long, subelliptical in outline, truncated on the cardinal margin, the hinge-line a little shorter than the greatest width. The dimensions of a nearly complete example are: length 3.8 mm., width 4.3 mm.

Pedicle valve adherent to foreign objects, all the specimens observed being attached to shells of *Platyceras,* its margin elevated and furnished with numerous, slender, often crowded and rather elongate, procumbent and attached spines which occur as commonly along the cardinal margin as elsewhere; cardinal area low and broadly triangular, with a narrowly triangular delthyrium closed by a deltidium; the hinge-teeth well developed, not supported by dental lamellæ.

Brachial valve with a small umbonal convexity in front of the beak, beyond which it becomes flat or concave; the surface marked by concentric lines of growth.

Remarks.—This species is of the type of *S. scintilla,* but grows somewhat larger, and is often proportionally more elongate. It differs especially from that species in the more numerous, more elongate, and more crowded spines of attachment which occur as commonly along the cardinal margin as elsewhere.

Horizon.—Keokuk (Crawfordsville shale, Indiana).

STROPHALOSIA CYMBULA Hall and Clarke

Plate XIX, Figs. 35-36

1892. *Strophalosia cymbula* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17A, figs. 3-4, 8-9.
1897. *Strophalosia cymbula* Hall, 14th Rep. N. Y. State Geol., p. 355, pl. 7, fig. 5.

Description.—Shell of about medium size or smaller, not attached in the mature condition, broader than long, the hinge-line nearly equaling the greatest width, the cardinal extremities angular. The dimensions of one of the co-types are: length 19.8 mm., width 22.5 mm., convexity of pedicle valve 7 mm., height of cardinal area 1.6 mm.

Pedicle valve moderately convex, the greatest convexity near the middle, the beak a little distorted, the cicatrix small and inconspicuous, the surface rather regularly convex except towards the cardinal ex-

tremities, where it is compressed; cardinal area broadly triangular, the cardinal margins sharply angular and nearly straight or gently convex from the beak to the cardinal extremities, its surface nearly flat and lying nearly in the plane of the valve; the delthyrium small, partially closed by the deltidium, which may be incomplete in the specimen observed. The surface covered with appressed spines of moderate size whose bases occur at intervals of about 2 mm. and tend to be arranged in radiating series, inconspicuous or absent from the umbonal region; surface marked also by inconspicuous concentric lines of growth.

Brachial valve concave, its curvature following somewhat closely that of the opposite valve, deflected towards the cardinal extremities; the beak inconspicuous; the cardinal area much narrower than that of the opposite valve; the surface marked by more or less irregular, concentric lines of growth with no spine bases.

Remarks.—This species, figured but not described by Hall and Clarke, is the largest which has been recognized in our Mississippian faunas. It resembles *S. beecheri*, but is larger, with more conspicuous spine bases upon the pedicle valve.

Horizon.—Kinderhook (New Providence shale, Kentucky).

Strophalosia beecheri Rowley

Plate XIX, Figs. 37-38

1893. *Strophalosia beecheri* Rowley, Am. Geol., vol. 12, p. 308, pl. 14, figs. 18-19.

1908. *Strophalosia beecheri* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 76, pl. 17, figs. 24-25.

Description.—Shell unsymmetrical, below medium size, not attached in the mature condition, broader than long, the hinge-line less than the greatest width, the cardinal extremities obtusely angular. The dimensions of the holotype, a pedicle valve, are: length 13.2 mm., greatest width 14.8 mm., length of hinge-line 11 mm., convexity 6 mm.

Pedicle valve most convex near the middle, the surface sloping with a gently convex curvature to the beak, to the antero-lateral and anterior margins, compressed towards the cardinal extremities, the umbonal region projecting slightly beyond the cardinal margin, the cicatrix small and inconspicuous; cardinal area rather narrow and nearly flat, lying in nearly the plane of the valve, the delthyrium small, closed by a convex deltidium. Surface marked by irregular, concentric lines of growth, and by rather strong spine bases which seem to be arranged in rather irregular concentric lines, the distances between the spines being about 2 mm. or somewhat less, the spines themselves have been destroyed but judging from the position of the bases they must have been nearly erect.

Brachial valve not known.

Remarks.—This species has been established upon a single unique specimen, a pedicle valve, which is not unlike, in its general appearance, a somewhat distorted pedicle valve of *Productella pyxidata*, with which it is associated. The presence of a well-defined cardinal area, however, excludes the specimen at once from the genus *Productella*. The species is somewhat similar to *S. cymbula*, but is smaller, with a relatively more convex pedicle valve, and with the surface spines more erect in position and not arranged in radiating series.

Horizon.—Louisiana limestone.

Family ORTHIDÆ

Genus *RHIPIDOMELLA* Oehlert

Description.—Shell subcircular or subovate in outline, biconvex and sublenticular, with the brachial valve somewhat the deeper. Hinge-line short, cardinal areas narrow, especially that of the brachial valve. The pedicle valve with two strong, diverging hinge-teeth, from the base of each a more or less strongly defined curved ridge extends anteriorly, bordering the muscular scar. The muscular area large, flabelliform, and deeply impressed, the margin thickened and elevated; the pedicle scar occupies the entire rostral cavity, the adductor scars rather small, narrow and elongate, entirely surrounded by the large diductor scars, from the narrow adductor scar a median ridge extends anteriorly, dividing the diductors. The brachial valve with deep and narrow dental sockets, the socket plates prominent, sometimes supporting short crura; the cardinal process erect, produced anteriorly in the floor of the valve as a median ridge; the muscular area small, quadripartite, usually indistinct. The surface of both valves marked by fine, rounded, subequal, hollow costæ, often opening on the surface, the openings probably representing the broken bases of fine, hollow spines.

Remarks.—In external features the members of this genus are much alike in outline and general contour of the shell, and practically all of them, except *R. dubia*, might from their external characters alone, be included in the European species *R. michelinia* as it has been interpreted by European authors. This interpretation of the American form has sometimes been suggested,[1] but a most careful study of many examples has brought out the fact that essentially all of the species which have been described from our American Mississippian faunas are good species, although their most essential characters have not always been pointed out, and that several additional species must be recognized.

The most important characters for use in the differentiation of species are the form of the cardinal process and socket plates of the brachial

[1] Weller, Bull. Geol. Soc. Am., vol. 20, p. 296 (1909).

valve, and the size and strength of the muscular impressions of both valves. Externally the species differ somewhat in general proportions, contour and surface markings, and although these differences are frequently slight, they correlate with the more marked internal features.

Rhipidomella missouriensis (Swallow)

Plate XX, Figs. 1-8

1860. *Orthis Missouriensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 639.
1892. *Orthis Missouriensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 6A, figs. 16-17.
1908. *Rhipidomella missouriensis* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser, p. 78, pl. 17, figs. 43-47.

Description.—Shell lenticular in form, of medium size or a little smaller, suborbicular in outline, usually a little wider than long, the greatest width a little anterior to the middle, the hinge-line much shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of two examples of about average size are: length of pedicle valve 19.7 mm. and 18.1 mm., length of brachial valve 19.1 mm. and 18 mm., greatest width 23.5 mm. and 20.5 mm., length of hinge-line 8.5 mm. and 9.5 mm., thickness 8 mm. and 9 mm.

Pedicle valve most convex in the umbonal region, the surface curving somewhat abruptly to the cardinal margin and compressed towards the cardinal extremities, broadly flattened in the median portion of the valve and becoming gently convex towards the antero-lateral and anterior margins; mesial sinus obsolete or present only as a slight depression close to the anterior margin; beak small, pointed, a little incurved; cardinal area small, concave, becoming more curved towards the beak, the inferior, flatter portion lying at an angle of about 45 degrees to the plane of the valve; delthyrium wider than high, its width at the base being from one-fourth to one-third the total width of the cardinal area. Internally the hinge-teeth are large, strong, and slightly diverging; the flabellate or subovate muscular scars reach anteriorly to the middle, or to a point beyond the middle of the valve, and are limited externally by a slightly raised border, the adductor impressions do not extend to the anterior margin of the entire scar, but a raised median ridge continues anteriorly to the limits of the diductor scars; the unpaired pedicle muscular scar occupies the rostral portion of the valve; its surface is slightly raised above that of the contiguous scars in front and is sharply differentiated from them; the anterior and lateral margins of the valve are slightly thickened and crenulate internally.

Brachial valve a little more convex than the pedicle, its greatest convexity near or a little posterior to the middle, the surface curving more

abruptly to the cardinal margin, slightly compressed towards the cardinal extremities, towards the anterior margin the surface is gently convex and towards the lateral margins a little more strongly so; the median portion of the valve is slightly flattened and is not infrequently a little impressed along the median line to form a very shallow, ill-defined sinus, which, with the slight flattening of the opposite valve, sometimes makes the outline of the shell a little emarginate in front; the beak is small, obtusely pointed and scarcely incurved; the cardinal area is a little smaller than that of the opposite valve and lies in nearly the plane of the valve. Internally the cardinal process is rather large and is continued as a flattened median ridge along the floor of the valve dividing the quadripartite muscular impression; the socket plates are prominent and widely diverging, with deeply excavated dental sockets; the muscular scars smaller and less deeply impressed than those of the opposite valve.

The surface of both valves marked by nearly uniform, rounded costæ, about three or sometimes four of which occupy the space of one millimeter, and which increase by bifurcation and intercalation; the shell substance is pierced by radiating canals or tubes which follow the direction of the costæ and which open at intervals to the exterior along the tops of the costæ. Regular, concentric lines of growth are usually present which often become more or less crowded towards the front margin.

Remarks.—This species may be distinguished from *R. burlingtonensis*, which it resembles, by its proportionally broader form, the smaller and less extended beak of the pedicle valve, by the somewhat more strongly developed radiating costæ and by the less frequent openings of the radial canals upon the shell surface, all of which are of uniform size. The size of the species is usually less than that of *R. burlingtonensis*.

Horizon.—Louisiana limestone.

Rhipidomella burlingtonensis (Hall)

Plate XXI, Figs. 5-7; Plate LXXXIII, Figs. 7-8

1858. *Orthis michelini* var. *burlingtonensis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 596, pl. 12, figs. 4a-b.
1874. *Orthis Michelini* var. *Burlingtonensis?* White, Prelim. Rep. Inv. Foss., p. 17.
1892. *Orthis Burlingtonensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 6A, fig. 13.
1892. *Orthis* (*Rhipidomella*) *Burlingtonensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 20, figs. 5-6.
1894. *Orthis burlingtonensis* Keyes, Mo. Geol. Surv., vol. 5, p. 63, pl. 38, fig. 7.

Description.—Shell of medium size or larger, subovate in outline, the length and width nearly equal or wider than long, the greatest width

near or a little anterior to the middle, the hinge-line less than one-half the greatest width of the shell, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 26.8 mm. and 24 mm., width 28.3 mm. and 25 mm., length of hinge-line 10 mm. and 11.8 mm., convexity 6.6 mm. and 6 mm. The dimensions of a large brachial valve are: length 28 mm., width 31.1 mm., convexity 6.5 mm.

Pedicle valve most convex posterior to the middle, the umbo rather prominent, the surface sloping abruptly to the cardinal margins, sometimes a little compressed towards the cardinal extremities, curving much more gently to the lateral and anterior margins; the mesial portion of the valve broadly and indefinitely flattened anterior to the middle, sometimes very slightly sinuate near the front margin; beak rather prominent; cardinal area small, concave, with the curvature increasing towards the beak, the lower, flatter portion sloping posteriorly at an angle of about 60 degrees to the plane of the valve, the lateral margins sharply defined, the delthyrium large and broadly triangular, its basal width sometimes occupying fully one-third of the total length of the hinge-line. Internally the cardinal teeth are of moderate strength and widely divergent; the muscular scars are large and flabellate with a slight raised marginal border, reaching beyond the middle of the valve anteriorly, sometimes being fully two-thirds the total length, with a width of from one-half to two-thirds the total width of the valve, the adductor scars are large and well defined, resting upon a somewhat elevated area near the middle of the entire muscular region which is continued anteriorly to the limits of the diductor scars in a raised median ridge somewhat narrower than the adductor scars themselves, the diductor scars are very large and are marked by several slight, subangular, radiating ridges, the unpaired pedicle muscle scar is large, occupying the entire rostral portion of the valve and is sharply differentiated from the contiguous scars in front; the inner margin of the valve is crenulate anteriorly and laterally.

Brachial valve subequally convex with the pedicle, the greatest convexity near the middle, the surface sloping with a gently convex curvature in all directions, the cardinal extremities sometimes slightly compressed; the mesial portion of the valve obscurely flattened or sometimes very slightly impressed in an ill-defined sinus; beak small, not incurved; cardinal area small, lying in nearly the plane of the valve. Internally the socket plates are prominent, with their anterior extremities almost cruralike in form; they rest upon the floor of the valve through almost their entire length and are widely divergent; the cardinal process is prominent and highly elevated, its posterior surface is nearly vertical and sometimes trilobate towards the apex, the anterior surface slopes obliquely to the floor of the valve and continues as a low, ill-defined mesial ridge to the anterior margins of the muscular scars; muscular scars smaller than

those of the opposite valve and less deeply impressed, quadripartite and subquadrate in outline; the inner margin of the valve crenulate anteriorly and laterally.

Surface of both valves marked by regular, uniform, depressed, rounded, radiating costæ, from two to three of which occupy one millimeter. The shell substance is pierced by radiating canals or tubules of two sizes, which apparently follow the direction of the costæ, the larger ones open at intervals along the summits of the costæ while openings of the finer ones cover the sides of the costæ and the furrows, giving to the shell, when a little weathered, the appearance of being punctate.

Remarks.—This species is characterized by the prominent umbo of the pedicle valve, by the greatly elevated cardinal process of the brachial valve and by the large size of the muscular scars in the pedicle valve. In size it is about equal to *R. oweni*, but it is proportionally longer and has a much more prominent umbo on the pedicle valve and nearly or quite obsolete sinus in the brachial valve. It differs from *R. jerseyensis* in its coarser surface costæ, the different position of the cardinal area of the pedicle valve, and in its much more prominent cardinal process. The punctate appearance of the shell surface is commonly more conspicuous in this species than in any of the others here described, but this may be due to the different condition of preservation.

Horizon.—Burlington limestone.

Rhipidomella oweni Hall and Clarke

Plate XXI, Figs. 1-4

1882. *Orthis Michelini* (*?*) Hall, Rep. N. Y. State Geol. for 1882, pl. (6) 36, figs. 19-21.
1892. *Orthis* (*Rhipidomella*) *Oweni* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, p. 342, pl. 6, figs. 19-21.
1897. *Orthis* (*Rhipidomella*) *Oweni* Hall, 14th Rep. N. Y. State Geol., p. 341, pl. 4, figs. 24-26.

Description.—Shell above medium size, lenticular in form, broader than long, with the greatest width anterior to the middle, the hinge-line about one-half or less than one-half the greatest width of the shell, the cardinal extremities rounded, the anterior margin nearly straight or somewhat emarginate in its median portion, curving regularly into the lateral margins at each side. The dimensions of two individuals are: length of pedicle valve 33 mm. and 27.5 mm., width 38 mm. and 32.3 mm., length of hinge-line 17 mm. and 17 mm., thickness approximately 9 mm. and 7 mm.

Pedicle valve most convex at a point about half way between the middle and the beak, the surface curving more abruptly to the cardinal margin, very slightly or not at all compressed towards the cardinal extremities,

sloping with a gently convex curvature to the lateral and anterior margins; the mesial portion of the valve scarcely or not at all differentiated from the general surface in the umbonal region, in the median portion of the valve and towards the front there is usually a low, ill-defined, rounded, mesial fold bounded by much narrower, equally ill-defined, shallow furrows, the top of the fold not being raised above the general convex curvature of the valve, near the front margin the median portion of the valve is commonly depressed to a slight degree in a broad, shallow, ill-defined sinus; the beak short and a little incurved; cardinal area small, concavely curved from the base to the apex, the lower, flattened portion sloping posteriorly from the plane of the valve at an angle of about 40 degrees, the lateral margins sharply defined, the delthyrium large, much broader than high, its width at the base about one-third, or nearly one-third, the total length of the hinge-line. Internally the cardinal teeth are strong and diverging, originating on either side of the delthyrium from the floor of the valve; the muscular scars are subovate in outline and rather small for this genus, their total length usually being less than one-half the length of the valve; they are rather deeply impressed, with a raised border, the adductor scars do not reach anteriorly as far as the diductors but in front of them, a distinctly elevated median ridge separates the two lobes of the diductor scars, the unpaired pedicle muscular scar occupies the rostral portion of the valve and is differentiated from the contiguous scars in front; beyond the muscular scars the inner surface of the valve is pitted or is covered with faint, anastomosing ridges, and along the lateral and anterior margins it is crenulated, the crenulations corresponding in size with the exterior costæ of the valve.

Brachial valve about equally convex with the pedicle, the greatest convexity a little posterior to the middle, the surface sloping with a gently convex curvature to the lateral and anterior margins, a little compressed towards the cardinal extremities; a shallow, rounded, ill-defined mesial sinus originates in the umbonal region and continues to the anterior margin; the beak small and short, not incurved; cardinal area smaller than that of the opposite valve, its surface lying in nearly the plane of the valve. Internally the cardinal process is rather small and low, rising from the posterior extremity of a rather broad, elevated ridge occupying the median line of the interior of the valve and extending anteriorly from the apex of the valve to an ill-defined termination near the anterior margins of the muscular scars; socket plates strong and widely diverging, resting upon the floor of the valve; the muscular scars shorter and a little wider than those of the opposite valve; the lateral and anterior margins of the valve crenulated internally.

Surface of both valves marked by numerous, uniform, depressed, rounded, radiating costæ, which increase by bifurcation and intercalation,

about two or three of which occupy the space of one millimeter at the outer margin of a mature specimen of average size. Regular, concentric growth lines are present upon both valves, sometimes rather uniformly distributed but usually more crowded towards the front; much finer concentric lines may be also detected upon some shells. The shell substance is pierced by radiating canals or tubules of two sizes, following the direction of the surface costæ, the larger ones apparently occupy the position of the median lines of the costæ, along the summits of which openings into the canals are present at irregular intervals, the finer canals occupy the slopes of the costæ and the intervening furrows, and upon slightly weathered specimens their openings are so numerous as to give to the shell a decided punctate appearance.

Remarks.—As commonly preserved the shells of this species are crushed and often distorted, but a sufficient number of undistorted examples, mostly detached valves, have come under observation to show all the essential features of the species. The species is especially characterized by its proportionally broader form and smaller muscular scars of the pedicle valve than is usual in the genus, and by the obscure and ill-defined mesial fold of the pedicle valve which is bordered on either side by an obscure rounded furrow. This latter character is not of sufficient strength to be preserved in the crushed examples, but in the undistorted valves it seems always to be present. The mesial sinus of the brachial valve is much stronger than the two furrows of the pedicle valve, and is a much more conspicuous feature than in *R. burlingtonensis*, the species which this one perhaps most closely resembles.

Horizon.—Kinderhook (New Providence shale, Kentucky).

RHIPIDOMELLA DIMINUTIVA Rowley

Plate XX, Figs. 9-18, 30-35

1900. *Rhipidomella diminutiva* Rowley, Am. Geol., vol. 25, p. 261, pl. 5, figs. 41-43.

Description.—Shell usually a little below medium size, subovate in outline, a little longer than wide or rarely with the length and breadth nearly equal, the greatest width anterior to the middle, the hinge-line from one-third to one-half the total width of the shell, the cardinal extremities rounded. The dimensions of three specimens are: length of pedicle valve 19 mm., 20 mm., and 19.3 mm.; length of brachial valve 18 mm., 19 mm., and 18.9 mm.; greatest width 17.4 mm., 18.8, and 19 mm.; thickness 8.8 mm., 10.2 mm., and 9 mm.; length of hinge-line 6.5 mm., 7.5 mm., and 6.9 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the cardinal margin, more gently to the lateral margins and still more gently to the anterior margin, slightly compressed towards the cardinal extremities; the median portion of the valve obscurely flattened

anteriorly or sometimes with a slight, ill-defined median sinus; the beak small, a little incurved, extending posteriorly only slightly beyond that of the opposite valve; cardinal area small, concave, with the curvature increasing towards the beak, the inferior, flatter portion sloping posteriorly at an angle of from 50 to 60 degrees to the plane of the valve, the lateral margins sharply defined; the delthyrium broadly triangular, much wider than high, its width at the base usually equal to about one-third the total length of the hinge-line. Internally the cardinal teeth are of moderate size and are widely divergent; the muscular scars are large, with their margin extending beyond the middle line of the valve, flabellate in outline, the adductor scars occupy a central, subcircular area, nearly one-third of the total length of the entire scar, which is distinctly raised above the general surface of the valve anteriorly and in front of which a gradually decreasing median ridge continues nearly to the limits of the diductor scars; the unpaired, median pedicle scar is very large, occupying the entire rostral portion of the shell and encroaching upon the adjacent scars in front from which it is sharply differentiated; the inner margin of the valve distinctly crenulate laterally and anteriorly.

Brachial valve equally or a little more convex than the pedicle, with the greatest convexity posterior to the middle, the surface curving more abruptly to the cardinal margin, more gently to the lateral margins and most gently to the anterior margins, usually a little compressed towards the cardinal extremities; a shallow, rounded, rather narrow, ill-defined median sinus originates in the umbonal region and continues to the anterior margin; the beak is inconspicuous, very obtusely pointed and not incurved; the cardinal area much smaller than that of the opposite valve, lying in nearly the plane of the valve. Internally the cardinal process is erect, rather prominent, and obtusely pointed at the summit, the posterior face is subcarinate along its median line, becoming obscurely trilobate towards the summit, and is nearly vertical to the plane of the valve, the anterior face is transversely rounded and slopes rather abruptly to the front and is extended anteriorly along the inner surface of the valve as a rounded median ridge which flattens out and becomes obsolete at the anterior extremity of the muscular scars; from either side of the cardinal process the socket plates originate and diverge widely, from the outer surface of each one a conspicuous lateral process limits the dental sockets, but beyond these processes the plates are produced into free, crura-like extensions; the muscular scars are distinctly quadripartite and are subquadrangular in outline, their anterior margin reaching to about the middle of the valve; the inner margin of the valve is distinctly crenulate anteriorly and laterally.

The surface of each valve is marked by fine, rounded, radiating costæ, three or four of which occupy the space of one millimeter. These costæ

are nearly uniform in size and increase by bifurcation and intercalation, they are crossed by concentric lines of growth which vary in strength and position on different individuals. The shell substance is pierced by radiating canals or tubules of two sizes, which follow the direction of the costæ, the larger ones open at more or less distant intervals along the summits of the costæ, and openings of the finer ones are closely crowded throughout the entire intervening space, giving to the shell when in proper condition of preservation a distinctly punctate appearance.

Remarks.—This species differs from *R. burlingtonensis* in its somewhat smaller size, its finer costæ, its more elongate outline, and its more distinct mesial sinus of the brachial valve. Besides these external differences, the cardinal process is not so prominent as in *R. burlingtonensis*, and the socket plates are more distinctly produced into crura-like extensions than has been observed in that species.

The species occurs near the summit of the Kinderhook and base of the Burlington limestone, occurring rather commonly in the white cherts of lower Burlington age at Louisiana, Missouri, which is the type locality. The species was originally described by Rowley from immature specimens about 6 mm. in length, the larger examples present in the same fauna being identified as *R. burlingtonensis*. A careful examination of specimens corresponding with the type of the species in size and in stage of development, and also of mature examples, has led the writer to the conclusion that the small shells are certainly the young of the larger ones, although the smaller examples are proportionally somewhat broader than the mature ones. There seems to be, however, sufficient reason for the separation of these shells from *R. burlingtonensis*, and consequently the name *R. diminutiva* must be extended to cover the mature as well as the younger representatives of the species.

Horizon.—Upper Kinderhook and lower Burlington limestone.

Rhipidomella thiemei (White)

Plate XXI, Figs. 8-27

1880. *Orthis thiemei* White, Contr. to Pal., No. 8, p. 164, pl. 41, figs. 4a-d.
1892. *Orthis Thiemii* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 6A, figs. 14-15.
1901. *Rhipidomella burlingtonensis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 181, pl. 16, fig. 6.
1904. *Rhipidomella thiemei* Girty, U. S. Geol. Survey, Prof. Paper No. 21, p. 48, pl. 10, figs. 1-2.

Description.—Shell small, subquadrate to subovate in outline, the length and width subequal or wider than long, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of an undersized but very complete specimen are: length of pedicle valve 7.5 mm., length of brachial valve 7.4 mm., greatest width 8.4 mm., length

of hinge-line 5 mm., thickness 4.3 mm. The length of one of the largest pedicle valves observed is 12 mm.

Pedicle valve depressed convex, the median portion of the valve broadly flattened from the beak anteriorly, the surface curving rather abruptly to the cardinal margin and much more gently to the lateral and anterior margins, very slightly or not at all compressed towards the cardinal extremities; mesial sinus originating near the mid-length of the valve and becoming rapidly deeper towards the front where it forms a rather conspicuous depression in the larger individuals; it is rounded in the bottom and ill-defined laterally; the beak is small, pointed and only a little incurved; the cardinal area is small, moderately incurved, of moderate height, and is not very sharply defined at its lateral margins; the delthyrium is large and open and occupies fully one-half the entire cardinal area. Internally the hinge-teeth are rather large and strong, and are supported by very short dental lamellæ; the flabellate muscular scars are large, reaching anteriorly beyond the middle of the valve, sometimes extending four-fifths the total length of the valve, the adductor scars are small, usually depressed below the general surface posteriorly, but elevated anteriorly and extended to the anterior margin of the diductor scars as an elevated ridge with gradually converging sides, the diductor scars very large and generally marked by radiating ridges.

Brachial valve a little deeper than the pedicle and more regularly convex, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins, the mesial portion of the valve sometimes slightly flattened, but usually not differentiated from the general curvature; the beak small, obtusely pointed and not incurved; the cardinal area very small and lying in nearly the plane of the valve. Internally the cardinal process is large, its posterior surface is divided by a median ridge which slopes from the highest point towards the beak, the anterior surface drops nearly vertically to the floor of the valve, along which the process is continued as a median ridge of greater or less strength to about the middle of the valve; the dental sockets are large and deep, the socket-plates are prominent and are produced anteriorly into slightly divergent, crura-like processes; the muscular scars are quadripartite, being smaller and much less deeply impressed than those in the pedicle valve.

The surface of both valves marked by fine, rounded, radiating costæ which increase by bifurcation, from four to five occupying the space of one millimeter. More or less inconspicuous, concentric lines of growth are also usually present.

Remarks.—This is one of the smaller species of the genus, being comparable in size to *R dubia.* and *R. jerseyensis* only. It differs from *R. jerseyensis,* with which it is similar in general form, in the conspicuous mesial flattening of the pedicle valve, and the well developed mesial sinus

in the anterior portion of the same valve, as well as in the absence of the mesial sinus of the brachial valve. From *R. dubia* it differs in its longer hinge-line and larger cardinal area, and in its more quadrangular outline.

Horizon.—Upper Kinderhook.

Rhipidomella jerseyensis n. sp.

Plate XX, Figs. 36-43

1909. *Rhipidomella michelinia* Weller, Bull. Geol. Soc. Am., vol. 20, p. 295, pl. 12, figs. 8-10.

Description.—Shell small, wider than long, broadly subovate, frequently emarginate in front, the greatest width anterior to the middle, the hinge-line less than one-half the greatest width of the shell, the cardinal extremities rounded. The dimensions of a nearly complete specimen of average size are: length of pedicle valve 14 mm., length of brachial valve 13 mm., maximum width 15 mm., length of hinge-line 6.5 mm., thickness 6.7 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, the cardinal extremities usually somewhat compressed; the median portion of the valve marked by an obscure, broadly rounded fold which is not defined laterally and which frequently becomes flattened out and obsolete anteriorly; the beak small, extending posteriorly only a short distance beyond the hinge-line; the cardinal area small, nearly flat or gently concave, its lateral margins sharply defined, sloping posteriorly at an angle of 30 degrees or less to the plane of the valve; the delthyrium large, broadly triangular, its width along the base being about one-third the total length of the hinge-line. Internally the cardinal teeth are of moderate strength and rather widely divergent; the muscular scars are of moderate size, extending anteriorly less than one-half the length of the shell from the beak, and are only slightly depressed below the general internal surface of the valve; the lateral and anterior margins crenulate internally.

Brachial valve nearly equally convex with the pedicle, its greatest convexity near or posterior to the middle, the surface sloping with a gently convex curvature in all directions, the cardinal extremities often a little compressed; the median portion of the valve marked by a distinct but shallow, rounded, median sinus, originating in the umbonal region and becoming stronger anteriorly, not sharply defined laterally; the beak small, not incurved; the cardinal area almost obsolete, lying in the plane of the valve. Internally the dental plates are rather prominent and widely divergent; the cardinal process is very small, rising slightly from the posterior extremity of a rather broad, low, median ridge which extends anteriorly along the floor of the valve to the anterior margin of the

muscular scars; muscular scars rather faint, their anterior margin not reaching to the middle of the valve, obscurely quadripartite; the lateral and anterior margins crenulate anteriorly.

Surface of both valves marked by fine, depressed, radiating costæ, about four or five of which occupy one millimeter along the front margin of an average size specimen. The costæ increase by bifurcation and intercalation and remain nearly uniform in size. Crossing the costæ upon well preserved shells there are exceedingly fine concentric lines, and stronger, more or less irregularly distributed concentric lines of growth. The shell substance is pierced by radiating tubules which follow the direction of the costæ, with openings at intervals along the summits of the costæ. Finer tubules, such as are present in *R. burlingtonensis*, have not been observed, although they may be present.

Remarks.—This species occurs in great numbers in the Fern Glen Kinderhook of Illinois and Missouri. It is characterized by its exceedingly fine costæ, by the distinct mesial sinus of the brachial valve, by the position of the cardinal area of the pedicle valve which slopes posteriorly more nearly in the plane of the valve than in any other of the species here described, and in the small size of the cardinal process. By one or more of the above characters the species may be distinguished from any of the other species.

In its typical expression this species is a small form, but associated with it are a smaller number of a much larger shell approaching *R. burlingtonensis* in size and form. The smaller specimens have usually been considered as being the immature examples of the larger form, but many of the small individuals give every evidence of being fully mature, and it is more than probable that two species are represented. The larger one does not exhibit the distinct mesial sinus of the brachial valve which is such a marked characteristic of the smaller one, the cardinal area of the pedicle valve does not lie quite so near the plane of the valve, the cardinal process is more prominent and the muscular impressions are somewhat larger. Most of these characters, however, except the sinus of the brachial valve which ought to persist, might be due to the greater age of the larger shells.

Horizon.—Fern Glen formation.

Rhipidomella tenuicostata n. sp.

Plate XX, Figs. 27-29

Description.—Shell small, lenticular in form, subovate in outline, varying from longer than wide to wider than long, the greatest width anterior to the middle, the hinge-line short, usually not exceeding one-third the width of the shell, the cardinal extremities rounded. The dimensions of two nearly perfect specimens are: length of pedicle valve 15.3 mm. and

10.2 mm., length of brachial valve 14.6 mm. and 9.9 mm., maximum width 16 mm. and 10 mm., length of hinge line 5 mm. and 3.2 mm., thickness 6.7 mm. and 4.8 mm.

Pedicle valve most convex posterior to the middle near the umbonal region, the surface curving abruptly to the cardinal margin and gently to the lateral and anterior margins, usually a little compressed towards the cardinal extremities; the mesial portion of the valve usually not differentiated from the general curvature of the surface; the beak small, a little incurved; the cardinal area very small, sloping posteriorly in an angle not exceeding 25 degrees to the plane of the valve, sometimes apparently lying almost in the plane of the valve; the delthyrium large, broadly triangular, its width along the base more than one-third the total length of the hinge-line. Internally the hinge-teeth are of moderate size and are widely divergent; the characters of the muscular scars have not been satisfactorily determined, but they do not extend anteriorly beyond the middle of the valve; the inner margins are crenulate anteriorly and laterally.

Brachial valve about equally convex with the pedicle, the greatest convexity near the middle, the surface curving to the margins rather gently in all directions, the cardinal extremities sometimes a little compressed; the mesial portion of the valve either not differentiated from the general curvature of the surface or depressed in a slight mesial sinus which is narrow, shallow and ill defined laterally; the beak shorter and more obtusely pointed than that of the opposite valve, not incurved; the cardinal area very small, lying in nearly the plane of the valve. Internally the cardinal process is large and strong, its posterior face transversely convex and sloping posteriorly from the summit at an angle of about 45 degrees to the plane of the valve, anteriorly it is continued along the median line of the inner surface of the valve as a conspicuous, broad, rounded ridge which reaches to about the middle of the valve; the socket plates flank the cardinal process on either side, and are abruptly bent to an anterior direction, and for the greater part of their length they are parallel with each other and with the median line of the valve; the characters of the muscular scars have not been clearly determined.

The surface of each valve is marked by exceedingly fine, nearly uniform, radiating costæ which increase by bifurcation and intercalation, about four or five occupying the space of one millimeter. The costæ are crossed by concentric lines of growth of moderate strength, varying in number and distribution upon different individuals. The shell substance is apparently perforated by radiating canals or tubules following the direction of the costæ, which open at intervals along the summits of the costæ; the presence of finer tubules in the intervening spaces is not clearly shown in any of the examples studied.

Remarks.—In its small size and fine costæ, this species agrees most closely with *R. jerseyensis*, but it differs externally from that species in being proportionally more elongate and in the entire absence or very slight development of a mesial sinus in the brachial valve. Internally this species is totally different from *R. jerseyensis* in the characters of the cardinal process and socket plates, the cardinal process being exceedingly large and prominent, while in that species it is small. The median ridge along the inner surface of the brachial valve is much more strongly developed than in any other member of the genus here described.

Horizon.—Chouteau limestone.

Rhipidomella dubia (Hall)

Plate XX, Figs. 22-26; Plate LXXXIII, Figs. 9-10

1856. *Orthis dubia* Hall, Trans. Albany Inst., vol. 4, p. 12.
1863. *Orthis Cooperensis* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 82.
1882. *Orthis dubia* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 45, pl. 6, figs. 1-5.
1883. *Orthis dubia* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 324, pl. 29, figs. 1-5.
1892. *Orthis dubia* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 12, figs. 10-13.
1892. *Orthis dubia* Hall and Clarke, Pal. N. Y., vol. 8, pt 1, pl. 6A, figs. 18-22.
1894. *Orthis dubia* Keyes, Mo. Geol. Surv., vol. 5, p. 64.
1906. *Rhipidomella dubia* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1303, pl. 22, figs. 1-4.

Description.—Shell small, usually a little longer than wide, subovate in outline, the greatest width usually anterior to the middle, the anterior margin nearly straight or slightly convex in the middle, sometimes slightly emarginate, the antero-lateral margins regularly rounded, the postero-lateral margins gently convex, becoming straighter as they approach the beak where they meet usually in an angle a little less than a right angle, the hinge-line very short; the two valves subequally convex. The dimensions of two individuals are: length of pedicle valve 14 mm. and 11.7 mm., length of brachial valve 13 mm. and 11 mm., greatest width 13.7 mm and 11.9 mm., thickness 8 mm. and 6.6 mm.

Pedicle valve flattened medially in its posterior half, the surface curving abruptly to the posterio-lateral margins, often with a slight incurvature to the cardinal extremities, and curving gently to the anterior and antero-lateral margins; mesial sinus rather broad and rather shallow, originating in or near the umbonal region, its lateral boundaries ill-defined, sometimes rather abruptly deepened as it approaches the anterior margin; the beak compressed, slightly or only moderately incurved; ear-

dinal area obsolete, the delthyrium rather large, about as wide or wider than high. Internally the hinge-teeth are large and strong, the muscular impressions large, flabellate, deeply impressed and usually extending two-thirds the length of the valve from the beak, the central or adductor impressions are situated upon a narrow, raised, median ridge; the anterior margin of the valve finely crenulated internally.

Brachial valve more rotund than the pedicle, with its greatest convexity near the middle or a little posterior to the middle, from which point the surface curves to the margins in all directions, the curvature being a little more abrupt to the postero-lateral margins; the mesial fold scarcely differentiated from the general convexity of the valve except sometimes near the anterior margin; the beak pointed and slightly incurved. Internally the cardinal process is large and strong, sometimes extending anteriorly from the beak for one-fourth the length of the valve; the muscular scars less deeply impressed than those of the opposite valve, divided along the median line by a narrow, elevated ridge; the anterior margin of the valve finely crenulate interiorly.

The surface of both valves marked by exceedingly fine radiating costæ, about three of which occupy the space of one millimeter at the front margin of a mature shell, these costæ are commonly worn away from the greater portion of the valves so that their surface appears to be nearly or quite smooth, but they may usually be detected in the mesial sinus near the front of the pedicle valve where the surface is more protected than elsewhere.

Remarks.—This species is a well-marked form, characterized by its small size, its short hinge-line and especially by the obsolete cardinal area, the marked flattening of the posterior portion of the pedicle valve and the more deeply depressed sinus near the front of the same valve than is common in the genus. The size of the species rarely exceeds that of the larger individual whose dimensions are given above, although the largest specimen observed has a length of 17 mm. and a width of 17.8 mm. The average size of the species is not far from that of the smaller example whose dimensions are given.

Horizon.—Keokuk limestone, Warsaw formation and Salem limestone.

Genus *SCHIZOPHORIA* King

Description.—Shell subcircular or subelliptical in outline, resupinate or with the valves subequally convex. Hinge-line shorter than the greatest width of the shell, the cardinal areas rather low. The pedicle valve with short dental plates which are continued as rather sharp ridges along the floor of the valve bounding the muscular area. The muscular scars of the pedicle valve less than half the length of the valve, obcordate or subovate in outline, more or less deeply impressed in the substance of the

valve and bordered by elevated margins, divided longitudinally by an elevated ridge upon which are situated the adductor scars. In the brachial valve the socket plates are erect and divergent; the cardinal process is similar to that of *Rhipidomella* but becomes resorbed and narrowed with age; the muscular scars are quadripartite and much less distinctly defined than those of the pedicle valve. Surface of both valves marked by fine, hollow, tubulose costæ, which are produced into short spines as in *Rhipidomella*.

Schizophoria subelliptica (White and Whitfield)

Plate XXIII, Figs. 1-5

1862. *Orthis subelliptica* White and Whitfield, Proc. Bost. Soc. Nat. Hist., vol. 8, p. 292.
1870. *Orthis subelliptica?* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 251.
1901. *Schizophoria subelliptica* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 182, pl. 16, figs. 4-5; p. 196, pl. 19, figs. 6-7.

Description.—Shell small, broader than long, transversely subelliptical in outline, the greatest width near the mid-length of the shell, the hinge-line about two-thirds the greatest width of the shell, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 10.8 mm. and 11 mm., width 13.5 mm and 13.8 mm., length of hinge-line 9 mm. and 9 mm., convexity 3.9 mm and 3.9 mm.

Pedicle valve most prominent on the umbo, curving abruptly to the cardinal margin and gently to the anterior and antero-lateral margins, compressed towards the cardinal extremities; the mesial portion of the valve distinctly flattened anteriorly and usually depressed in an exceedingly shallow, rather broad and ill-defined sinus; the beak pointed, rather prominent, a little incurved; cardinal area of moderate size, concave, the curvature increasing towards the beak, the lower, flatter portion lying at nearly a right angle to the plane of the valve, its lateral margins sharply defined. Internal characters not observed.

Brachial valve not observed.

Surface marked by fine, rounded, radiating costæ, increasing by bifurcation and intercalation, every second or third one of which is slightly larger, about four or five occupying the space of one millimeter at the front of a mature shell 11 mm. in length. The shell substance pierced by radiating canals or tubules which follow the direction of the costæ, along the summits of the larger of which, the canals open at irregular intervals. Crossing the radiating costæ are regular, concentric lines of growth, usually obscure or obsolete except near the margin where several are crowded together.

Remarks.—In its typical expression this species has been recognized only in the fauna of the Kinderhook oolite bed at Burlington, Iowa,

although the cotypes of the species include specimens from the superjacent bed at the same locality. These latter specimens, however, grow to a much larger size, besides differing in some other respects, and should possibly be referred to the species here described as *S. chouteauensis*. In some respects *S. subelliptica* suggests a diminutive *S. swallovi*, but the surface of the pedicle valve is much less flat than that species, with the beak and umbo proportionally more prominent. The radiating costæ are also less nearly uniform in size in this species, with the external openings of the radiating canals restricted to the larger costæ. The brachial valve has not been available for study, but it is believed that it much more nearly equals the pedicle valve in convexity than in *S. swallovi*, in which species the convexity of the brachial valve greatly exceeds that of the pedicle.

Horizon.—Kinderhook.

Schizophoria chouteauensis n. sp.

Plate XXIII, Figs. 6-19

Description.—Shell of medium size or smaller, broader than long, transversely subelliptical in outline, the greatest width near the mid-length of the shell, the cardinal extremities rounded. The dimensions of two nearly perfect individuals are: length of pedicle valve 19.9 mm. and 12 mm., length of brachial valve 19 mm. and 11.8 mm., greatest width 22.8 mm. and 14.2 mm., length of hinge-line 14.4 mm. and 10 mm., thickness 11.2 mm. and 7 mm.

Pedicle valve most convex near the umbo, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins, a little compressed towards the cardinal extremities; mesial sinus entirely obsolete; umbo prominent with the beak rather small and a little incurved; the cardinal area small, its lateral margins well defined, concave with the curvature increasing towards the beak the lower and flatter portion lying at nearly a right angle to the plane of the valve. Internally the cardinal teeth are supported by short dental lamellæ which continue anteriorly along the inner surface of the valve as raised ridges bounding the muscular scars laterally; the muscle scars fall short of reaching the middle of the valves anteriorly, they are subcordate in outline with a deep, acutely angular emargination in front, and are divided longitudinally by a raised, subangular ridge, which is highest anteriorly at the base of the emargination and is rather rapidly reduced in height posteriorly.

Brachial valve a little more convex than the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, compressed towards the cardinal extremities; the mesial portion of the valve

slightly flattened but not differentiated from the general curvature of the surface; beak smaller than that of the opposite valve and a little more incurved, projecting posteriorly beyond the cardinal line nearly as far as that of the pedicle valve; cardinal area much smaller than that of the opposite valve, lying in nearly the plane of the valve. Internal characters not observed.

Surface of both valves marked by fine, rounded, radiating costæ of nearly uniform size, which increase by bifurcation and intercalation, from three to four of which occupy the space of one millimeter at the front of a specimen about 20 mm. in length; crossing the radiating costæ there are regular concentric lines of growth which commonly become stronger and more crowded towards the front. The shell substance is pierced by radiating canals or tubules which follow the direction of the costæ, along the top of which they open at intervals.

Remarks.—This species resembles *S. subelliptica* but, besides being larger, it lacks the distinct mesial flattening of the pedicle valve and the slight depression near the front margin. On comparing examples of this species which correspond in size with mature specimens of *S. subelliptica,* the costæ are considerably finer, there being as many as five in the space of one millimeter in an example 12 mm. in length at its front margin. The species differs from *S. swallovi* in its much smaller size, in the absence of the distinct flattening of the pedicle valve and in the more nearly equal convexity of the two valves.

Horizon.—Chouteau limestone of the Kinderhook.

Schizophoria sedaliensis n. sp.

Plate XXI, Figs. 28-32

Description.—Shell above medium size, broader than long, subelliptical in outline, the greatest width near the mid-length, hinge-line shorter than the greatest width, cardinal extremities rounded. The dimensions of a nearly complete individual are: length of pedicle valve 30.5 mm., length of brachial valve 30 mm., greatest width 36 mm., length of hinge-line 22 mm., thickness 17.8 mm.

Pedicle valve most convex posterior to the middle, the umbo a little depressed, the surface curving abruptly to the cardinal margin and gently to the lateral and anterior margins, somewhat compressed towards the cardinal extremities; mesial portion of the valve broadly flattened towards the anterior margin; beak small, a little incurved; cardinal area small, sharply defined along its lateral margins, concave, with the curvature increasing towards the beak; the delthyrium broadly triangular. Internally the cardinal teeth are supported by short dental plates which are continued as low, angular ridges along the lateral margins of the muscular scars; muscular scars subovate in outline, less than one-half the

length of the valve, not emarginate in front, divided longitudinally along the median line by an abruptly elevated angular ridge which is highest near the front and is gradually reduced in height towards the beak, in front of the muscular scar the median ridge is produced anteriorly as a flattened rib upon the inner surface of the valve.

Brachial valve more convex than the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, compressed towards the cardinal extremities; the median portion of the valve either not differentiated from the general curvature of the surface or broadly and indefinitely flattened from the umbonal region to the front; the umbo a little produced beyond the cardinal margin, the beak small and incurved; the cardinal area small, lying in nearly the plane of the valve. Internally the socket plates are prominent and widely divergent, the cardinal process is small, and is not produced as a median rib along the median line of the inner surface of the valve; the muscular scars are subovate in outline and are about equal in size to those of the opposite valve.

Surface of both valves marked by fine, radiating, rounded costæ which increase by bifurcation and intercalation, and about three of which occupy the space of one millimeter near the front of a mature example. The costæ are crossed by a few more or less indistinct, concentric lines of growth. The tubular nature of the costæ has not been observed.

Remarks.—This species most closely approaches *S. swallovi* in its characteristics, but it differs from that species in the more convex pedicle valve and in the more nearly equal convexity of the two valves. Internally the shape of the muscular scars of the pedicle valve differs from those of *S. swallovi* in being without the emargination in front, and in having the median septum which divides the muscular scar longitudinally, produced anteriorly as a depressed ridge. In general contour the species most closely resembles *S. chouteauensis*, but it is larger than that species and has the pedicle valve indefinitely flattened towards the front, besides having the same difference in the form of the muscular scar of the pedicle valve as between it and *S. swallovi*.

Horizon.—Upper Chouteau limestone.

Schizophoria poststriatula n. sp.

Plate XXII, Figs. 7-14 (?15-17)

1909. *Schizophoria swallovi* Weller, Bull. Geol. Soc. Am., vol. 20, p. 296, pl. 12, figs. 6-7.

Description.—Shell resupinate, above medium size, wider than long, subelliptical in outline, the greatest width near the mid-length of the

shell, the hinge-line a little more than one-half the width of the shell, the cardinal extremities rounded. The dimensions of a nearly complete, somewhat crushed specimen, are: length of pedicle valve approximately 30 mm., length of brachial valve approximately 30 mm., greatest width 36.5 mm., length of hinge-line 20 mm., thickness 23 mm., convexity of pedicle valve 8.2 mm., height of cardinal area 4 mm. The dimensions of another nearly perfect but somewhat unsymmetrical specimen are: length of pedicle valve 28 mm., length of brachial valve 28.3 mm., greatest width 32.1 mm., thickness 19.2 mm , length of hinge-line 18.5 mm.

Pedicle valve much less convex than the brachial, most prominent on the umbo, the surface sloping rather abruptly to the cardinal margin, and more gently to the lateral and antero-lateral margins, compressed towards the cardinal extremities; the mesial portion of the valve slightly flattened in the posterior portion, becoming impressed anteriorly in a distinct, rounded mesial sinus of moderate depth; the beak moderately prominent and a little incurved; cardinal area of moderate size, its lateral margins well defined, its surface concave with the curvature increasing towards the beak, the lower flattened portion with a slight posterior slope from the hinge-line; the delthyrium of moderate size, about as wide as high. Internally the cardinal teeth are supported by short dental lamellæ which are continued anteriorly along the inner surface of the valve as elevated ridges along the lateral margins of the muscular scar; muscular scar subcordate in outline with an angular emargination in front, less than one-half the total length of the valve, divided longitudinally by a strong, subangular, median ridge which is highest in front opposite the emargination of the muscular region, gradually decreasing in prominence posteriorly.

The brachial valve much more strongly convex than the pedicle, most prominent near the middle, the surface curving abruptly to the margin in all directions, slightly compressed towards the cardinal extremities, the umbo prominent and projecting conspicuously backward beyond the hinge-line; the mesial portion of the valve slightly differentiated anteriorly in a low, rounded, ill-defined mesial fold; beak pointed, much more strongly incurved than that of the opposite valve; cardinal area about one-half as wide as that of the pedicle valve, concave, its lateral margins sharply defined, its inferior portion lying in nearly the plane of the valve and towards the apex curving towards the beak of the opposite valve. Internal characters not observed.

Surface of each valve marked by fine, rounded, nearly uniform, radiating costæ which increase by bifurcation and intercalation, about three costæ occupy the space of one millimeter, the intervening furrows about equaling the costæ in width; crossing the radiating costæ there are numerous, regular, concentric lines of growth which become stronger and more

crowded anteriorly where they are sometimes subimbricating. The shell substance is pierced by radiating canals or tubules which open at intervals along the summits of the costæ.

Remarks.—This species has commonly been included in *S. swallovi,* but besides occurring at a lower horizon it possesses well-marked distinguishing characters. It never attains so great a size as *S. swallovi,* its pedicle valve is never so flat, it possesses a distinct mesial sinus toward the front of the pedicle valve, and instead of a slight mesial depression towards the front of the brachial valve there is a tendency towards a slight elevation or fold. In all these characters the species approaches the Devonion *S. striatula,* and it is essentially a form intermediate in character between this species and *S. swallovi.*

Horizon.—Fern Glen formation.

SCHIZOPHORIA SWALLOVI (Hall)

Plate XXII, Figs. 1-6

1848. *Orthis resupinata* Christy, Letters on Geology, pl. 3, figs. 1-2.
1858. *Orthis swallovi* Hall, Geol. Iowa, vol. 1, pt. 2, p. 597, pl. 12, figs. 5a-b.
1883. *Orthis Swallovi* Hall, Rep. N. Y. State Geol. for 1882, pl. (6) 36, figs. 23, 24.
1892. *Orthis Swallovi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 6, figs. 23, 24.
1894. *Orthis swallovi* Keyes, Mo. Geol. Surv., vol. 5, p. 63, pl. 38, fig. 5.

Description.—Shell large, resupinate, broader than long, transversely subelliptical in outline, often slightly emarginate in front, the hinge-line about one-half or a little more than one-half the greatest width, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 41 mm. and 38.5 mm., width 51.7 mm. and 49 mm., length of hinge-line 31 mm. and 23 mm., height of cardinal area 6 mm. and 4 mm., convexity 9.2 mm. and 7.5 mm. The dimensions of a brachial valve are: length 39.6 mm., width 46.2 mm., convexity 14.3 mm.

Pedicle valve nearly flat or only slightly convex over the greater portion of its surface, most prominent in the umbonal region, curving somewhat abruptly to the cardinal margin, a little compressed towards the cardinal extremities; the median portion of the valve usually undifferentiated in the posterior half of the valve and becoming slightly depressed towards the front in a broad, shallow and undefined sinus, occasionally this sinus originates in the umbonal region, and sometimes it is slightly more depressed at either side towards the front with the median portion a little higher; beak rather small, only moderately produced beyond the hinge-line posteriorly; cardinal area rather small, concave, with the curvature increasing towards the beak, broadly triangular, the lateral margins well defined and usually slightly concave in passing from the beak

to the cardinal extremities, the inferior, flatter portion lying nearly at a right angle to the plane of the valve; the delthyrium large, broadly triangular. Internally the cardinal teeth are of moderate size, and are supported by short dental lamellæ which are continued anteriorly as low bounding ridges along the lateral margins of the muscular scars; the muscular scars rather large, sometimes extending anteriorly beyond the middle of the valve, sharply defined all around by a margin which is abruptly raised from the inner surface of the valve, subcordate in outline with a deep and acutely angular emargination in front, divided longitudinally from the base of the emargination to the beak by a conspicuous, narrowly rounded, median ridge which gradually decreases in size posteriorly; each lateral lobe marked by several ill-defined, more or less inconspicuous, radiating ribs which are strongest anteriorly.

Brachial valve much more convex than the pedicle, the greatest convexity posterior to the middle, the umbo prominent and extending conspicuously beyond the cardinal margin, the surface curving abruptly to the margin on all sides but most abruptly to the cardinal margin, somewhat compressed towards the cardinal extremities; the median portion of the valve distinctly flattened posteriorly, the flattened region becoming impressed towards the front in a shallow, rounded sinus of moderate width; the beak pointed and rather strongly incurved; the cardinal area smaller than that of the opposite valve, its lateral margins sharply defined, concave, curving from the hinge-line towards the beak of the opposite valve. The internal characters of the valve not observed.

Surface of both valves marked by fine, regular, radiating costæ which increase by bifurcation and intercalation, about two or three occupying the space of one millimeter at the front of a full grown shell, crossing the costæ are more or less irregular concentric lines of growth which are commonly more conspicuous upon the brachial valve, and are usually somewhat crowded near the margin of full grown shells. The shell substance is pierced by fine, radiating canals or tubules which apparently follow the direction of the radiating costæ, along the summit of which they open at intervals.

Remarks.—This is the largest of our species of *Schizophoria,* and is a common and characteristic fossil of the Burlington limestone. It may be easily recognized by its large size and the very slight mesial sinus of the pedicle valve.

Horizon.—Burlington limestone.

Family PENTAMERIDÆ

Genus *CAMAROPHORIA* King

Description.—Shell usually small or below medium size, rostrate, subovate to subpentagonal in outline, with well-developed median sinus in the pedicle valve and fold in the brachial valve, both valves either plicated or with the plications nearly or quite obsolete. In the pedicle valve the dental lamellæ are continued anteriorly into a well developed spondylium which is either supported by a median septum or rests directly upon the floor of the valve for a part or the whole of its length. In the rostral portion of the brachial valve the hinge-plate is continuous and is supported by a strong median septum; between the hinge-plate and the floor of the valve the median septum also supports a concave cruralium which is continued far beyond the hinge-plate, becoming broader and more highly elevated anteriorly; posteriorly the median septum passes through the cruralium for the support of the hinge-plate, but the extension of the septum above the concave surface of the cruralium soon disappears beyond the anterior margin of the hinge-plate.

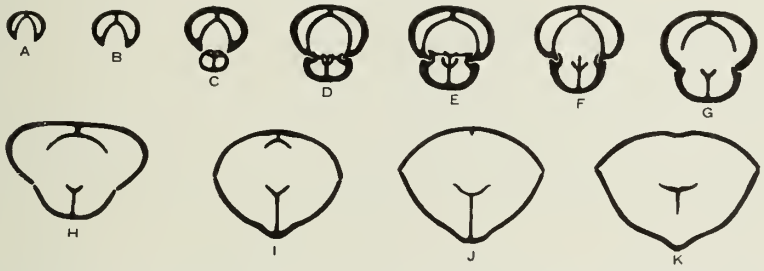

Fig. 1.—A series of eleven cross-sections (× 2½) of the rostral portion of *Camarophoria schlotheimi* (von Buch), the genotype of *Camarophoria*, from the Permian of Possneck, Germany, showing dental lamellæ and spondylium of the pedicle valve, and the median septum, cruralium and hinge-plate of the brachial valve.

Remarks.—Sometimes the genus *Camarophoria* has been so interpreted as to include a number of rhynchonelloid shells, *R. subcuneata* and *R. subtrigona*, of our Mississippian faunas which are characterized by a median septum in both valves. These shells, however, do not possess the cruralium of the brachial valve and are therefore excluded from the family *Pentameridæ* and are included in the present report in the *Rhynchonellidæ* under the genus *Tetracamera*. In all the species here included in *Camarophoria* the characteristic internal characters of the shell have been determined by grinding the rostral portion of the shells. For comparison similar sections of the genotype, *C. schlotheimi* (von Buch), have been made and the American Mississippian species agree in all essential generic characters with that species from the Permian of Germany.

Camarophoria hamburgensis Weller

Plate XXIII, Figs. 52-60

1910. *Camarophoria hamburgensis* Weller, Bull. Geol. Soc. Am., vol. 21, p. 500, fig. 2.

Description.—Shell below medium size, subovate in outline, the length equal to, greater or less than the width, the greatest width near the mid-length of the shell. The postero-lateral margins nearly straight, and meeting at the beak in an angle, the lateral and anterior margins rounded. The dimensions of a small but nearly perfect specimen are: length 9.4 mm., width 9.3 mm., thickness 5.5 mm. The dimensions of two detached brachial valves are: length 10.5 mm. and 10 mm., width 13.5 mm. and 12.4 mm.

Pedicle valve depressed convex in the posterior half and towards the antero-lateral margins, more strongly arched from the beak to the anterior margin, along the postero-lateral margins the edge of the valve is rather abruptly inflected towards the opposite valve to form a false cardinal area; mesial sinus obsolete in the posterior half of the valve, originating near the middle and continuing to the anterior margin as a broad, shallow, illdefined, regularly concave depression, whose surface curves towards the opposite valve anteriorly and is a little produced in front as a broad rounded extension; beak rather large, a little incurved, pierced by a subcircular foramen; delthyrium broadly triangular, nearly filled by the beak of the opposite valve, its apex communicating with the foramen which encroaches upon the beak of the valve; plications depressed,

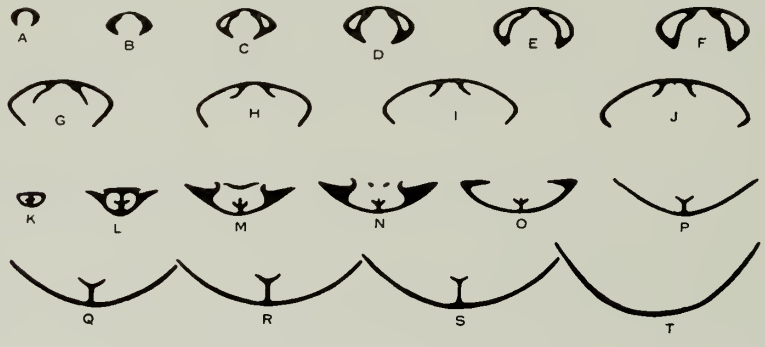

Fig. 2.—A series of cross-sections of the rostral portion of the shell of *Camarophoria hamburgensis* (× 2½); A to J the pedicle valve; K to T the brachial valve.

mostly simple, rather broad and rounded on top, originating at or near the beak, from 16 to 22 in number, from 5 to 7 of which occupy the mesial sinus, those towards the postero-lateral margins becoming faint or nearly obsolete. Internally the hinge-teeth are supported by dental lam-

cllæ which are produced anteriorly more than one-third the length of the valve as a spondylium-like platform which rests upon the floor of the valve, not being raised on a median septum.

Brachial valve more convex than the pedicle, the greatest convexity near the middle, the surface curving downward in all directions from the point of greatest convexity but more gently to the anterior margin than in other directions; mesial fold obsolete in the posterior half of the valve, only moderately elevated in front, rounded transversely and sometimes scarcely differentiated from the lateral slopes; the beak broad, strongly incurved beneath that of the opposite valve; the plications similar in form and number to those of the opposite valve. Internally no cardinal process is present, the hinge-plate is broad and not divided and is produced anteriorly in a pair of crura, at the apex of the beak it is supported by a median septum from each side of which, at a position about midway between the hinge-plate and the floor of the valve, springs a lateral process which curves slightly away from the floor of the valve, anteriorly the hinge-plate becomes entirely unsupported by the median septum before the articulation of the hinge is past, but the median septum itself with its transverse processes which develop into a broadly V-shaped platform extends for one-third or more of the length of the valve, the platform gradually rising higher above the floor of the valve and terminating abruptly with the septum in front, posteriorly the median septum continues for a short distance towards the front as a gradually decreasing longitudinal ridge in the bottom of the V-shaped platform.

The surface of both valves, in addition to the plications, is marked by more or less obscure lines of growth.

Remarks.—In its external aspects this little shell resembles, to some extent, some of the Devonian species of *Pentamerella*, but its internal characters are not essentially different from those of *Camarophoria*, in which genus the species is placed without any hesitation. The spondylium-like platform of the pedicle valve resting upon the floor of the valve, is similar to the condition in *Camarophorella*, and the median septum of the brachial valve with its transverse processes is also similar to that genus, but it lacks the lateral septa which in that genus connect the outer margins of the V-shaped platform with the floor of the valve. *Camarophorella* has been shown recently to be a spire bearing shell,[1] but there is no evidence in the specimens of the species here described that this form possessed any brachidium beyond the crura, although if such had been present it would have been destroyed in the separated valves which alone have been available for the examination of the internal parts. Externally, the shell is distinctly unlike *Camarophorella* in having distinct longitudinal plications.

[1] Hyde, Proc. Boston Soc. Nat. Hist., vol. 34, No. 3, pp. 35-65 (1908).

Among the numerous examples of the species which have been examined, a considerable amount of variation is exhibited in the proportional length and breadth of the shells and in the strength of the plications. An occasional example is found upon which the plications are essentially obsolete, and others occur on which they are obsolete towards the beak, but in all other respects, both external and internal, so far as they can be examined, they are identical with the plicated examples, and all are believed to belong to a single species.

Camarophoria bisinuata (Rowley)

Plate XXIII, Figs. 20-45

1900. *Seminula bisinuata* Rowley, Am. Geol., vol. 25, p. 263, pl. 5, figs. 21-24.

1909. *Camarophoria bisinuata?* Weller, Bull. Geol. Soc. Am., vol. 20, p. 301.

Description.—Shell small, subovate to subpentagonal in outline, more or less subglobular in form, the length greater or a little less than the width, the greatest width near or in front of the middle of the shell. The dimensions of two examples, metatypes, are: length of pedicle valve 9.2 mm. and 9 mm., length of brachial valve 8.4 mm. and 8 mm., greatest width 9.8 mm. and 8.3 mm., thickness 6.1 mm. and 6.3 mm.

Pedicle valve arched from beak to front, moderately convex in the umbonal region, the curvature of the surface is abrupt and somewhat inflected from the umbonal region to the cardinal margin, and more gentle to the antero-lateral margins; mesial sinus obsolete in the posterior half of the valve, rather broad and shallow anteriorly, deepest towards its lateral margins with a low, broad, rounded fold in the middle, produced anteriorly in a lingual extension whose surface lies at nearly a right angle to the plane of the valve; beak small, pointed and moderately incurved; plications wanting except the broad, low, median fold which is usually present in the sinus. Internally, a strong median septum about one-third the length of the valve extends anteriorly from the beak, and supported by this septum is a distinct spondylium.

Brachial valve more strongly convex than the pedicle, becoming gibbous in the more globular examples, the greatest depth anterior to the middle and sometimes close to the anterior margin, the surface curving abruptly from the middle to the posterior, lateral and antero-lateral margins; the median portion of the anterior half of the valve is elevated in a mesial fold which sometimes gives to the anterior portion of the valve a trilobed appearance, along its median line the fold is marked by a furrow which is commonly narrower than the median plication of the opposite valve; the beak is pointed and incurved beneath that of the opposite valve; plications absent from the lateral slopes as in the pedicle

valve. Internally a median septum, thinner and weaker than that of the pedicle valve extends anteriorly from the beak, and supports both the cruralium and the hinge-plate.

The surface markings of the shell consist of rather strong, more or less regularly arranged concentric lines of growth.

FIG. 3.—A series of five cross-sections of the rostral portion of the shell of *Camarophoria bisinuata* (× 2½).

Remarks.—This species was originally described as a member of the genus *Seminula*, now known under the name *Composita*, and in its general form it does resemble members of that genus. Some examples, even closely resemble small specimens of *C. trinucleа*, and under certain conditions of preservation it might be difficult to separate the forms, but internally the two shells are fundamentally different, the median septum and spondylium being entirely wanting in *Composita*. The only other species of *Camarophoria* with which it is necessary to compare this one is *C. explanata*. The more globular examples of *C. bisinuata* most closely resemble *C. explanata*, but they may always be distinguished by the absence of any plications upon the lateral slopes of the valves.

Horizon.—Fern Glen formation and lower Burlington limestone.

CAMAROPHORIA EXPLANATA (McChesney)

Plate XXIII, Figs. 46-51

1860. *Rhynchonella explanata* McChesney, Desc. New Pal. Foss., p. 50.
1865. *Rhynchonella explanata* McChesney, Plates Ill. New Spec. Foss., pl. 6, figs. 7a-c.
1868. *Rhynchonella explanata* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 30, pl. 6, figs. 7a-c.
1894. *Pugnax explanatus* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 44, figs. 14-16.
1895. *Pugnax explanatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 43-45.
1897. *Camarophoria explanata* Schuchert, Bull. U. S. Geol. Survey No. 87. p. 162.
1910. *Camarophoria explanata* Weller, Bull. Geol. Soc. Am., vol. 21, p. 501, fig. 3.

Description.—Shell small, subglobular in form, usually a little wider than long. The dimensions of the type specimen, which is a little above the average size, are: length 8 mm., width 8.9 mm., thickness 7.5 mm. One of the largest examples observed has a length of 10 mm., but the

average size is probably a little less than that of the type specimen whose dimensions have been given.

Pedicle valve strongly convex, the greatest convexity nearest the middle, the surface strongly arched from beak to front and also transversely, the slope from the umbonal region most abrupt towards the cardinal margin, more gentle to the lateral margins; mesial sinus obsolete in the posterior half of the valve, developed as a broad, shallow depression anteriorly and somewhat produced in front in a lingual extension whose surface is nearly at right angles to the plane of the valve; beak small, pointed, incurved; plications obsolete posteriorly, in the anterior half of the shell they are broad and rounded, a single strong one, the strongest one on the valve occupies the median portion of the sinus, and upon each lateral slope of the valve there are two or three weaker ones. Internally a strong median septum is developed, supporting a spondylium, which extends anteriorly from the beak for one-third or one-half the length of the valve.

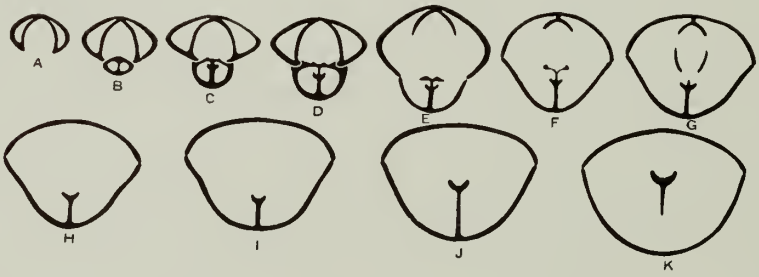

FIG. 4.—A series of eleven cross-sections of the rostral portion of the shell of *Camarophoria explanata* (× 2½), showing the spondylium and the manner of development of the cruralium and its relation to the hinge-plate.

Brachial valve gibbous, more strongly convex than the pedicle, the greatest convexity near the middle, the surface curving steeply from the middle point to the posterior, lateral and antero-lateral margins and more gently to the anterior margin; mesial fold obsolete in the posterior half of the valve and only moderately elevated in front, it is divided into two rounded folds by a median rounded furrow which originates near the middle of the valve to correspond with the median plication of the sinus of the opposite valve; the beak is strongly incurved beneath that of the opposite valve; the plications are similar to those of the opposite valve; besides the two plications of the fold, already mentioned, there are two or three upon each lateral slope, none of which originate posterior to the middle of the valve and the smaller ones even nearer to the margin. Internally this valve has a median septum extending forward from the beak, but it is thinner and more feebly developed than that of the pedicle valve; it supports the cruralium and the hinge-plate.

The surface is marked only by concentric lines of growth which are irregularly developed, frequently being obscure or wholly obsolete.

Remarks.—In its general form this species resembles members of the rhynchonelloid genus *Pugnax,* but it differs fundamentally from members of that genus in having a distinct spondylium in the pedicle valve supported by a median septum. This septum, and also that of the opposite valve, is almost always clearly recognizable, except in silicified specimens, as a dark line extending anteriorly from the beak. Hall and Clarke referred the species to *Pugnax* doubtless because the specimen which they studied and illustrated was a very perfect sulphur cast of McChesney's type specimen, but upon which there was, of course, no color differentiation which would lead to the recognition of a septum.

The species is very distinct from all other members of the genus in our American Mississippian faunas, and can be confused with none of them. It occurs abundantly in some of the Chester faunas where it is a highly characteristic species.

Horizon.—Chester group.

Order TELOTREMATA

Family RHYNCHONELLIDÆ

Genus *CAMAROTŒCHIA* Hall and Clarke

Description.—Shell rhynchonelliform, small or below medium size, subovate, subpentangular or subtriangular in outline. The mesial fold and sinus well developed, the surface of both valves marked by angular or subangular plications which extend to the beak, the plications not medially grooved in front. In the pedicle valve the hinge-teeth are rather small and are supported by slender, vertical, dental lamellæ. In the brachial valve a well-defined median septum is present in the rostral portion of the valve which is divided internally to form a V-shaped crural cavity, the hinge-plate is divided, the inner margin of each lateral portion being supported by one of the lateral walls of the crural cavity; no cardinal process is present and the crura are formed by the anterior extension of the inner margins of the two divisions of the hinge-plate.

Remarks.—The essential generic characters of *Camarotœchia* are found in a combination of the internal and external features of the shell. The median septum of the brachial valve supporting the V-shaped crural cavity and the divided hinge-plate are identical in all essential respects with the rostral characters of *Wilsonia, Liorhynchus, Paryphorhynchus* and *Pugnoides,* the five genera being differentiated one from another by constant external characters. In *Wilsonia* the shell is subcubical in form with the plications flattened anteriorly and longitudinally grooved, especially in the fold and sinus. *Liorhynchus* is a larger shell with the

plications usually nearly obsolete upon the lateral slopes of the valves. *Paryphorhynchus* also is a much larger shell with the entire external surface of the valves marked by fine radiating striæ in addition to the plications, and *Pugnoides* has the plications becoming obsolete towards the beak.

Camarotœchia choutcauensis Weller

Plate XXIV, Figs. 34-40

1910. *Camarotœchia choutcauensis* Weller, Bull. Geol. Soc. Am., vol. 21, p. 510, fig. 10.

Description.—Shell small and thick, triangularly subovate in outline, wider than long, the greatest width near or in front of the middle, the postero-lateral margins meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin gently convex. The dimensions of two nearly perfect specimens are: length 11 mm. and 9.3 mm., width 11.5 mm. and 10 mm., thickness 10 mm. and 8 mm., width of sinus in front 7 mm. and 5.6 mm.

Pedicle valve shallow, narrowly convex on the umbo, the surface sloping from the umbo to the cardinal margin, at first with an abrupt convex curvature, becoming gently concave as it approaches the margin, towards the antero-lateral margins the surface is gently convex and from the beak to the front along the median line it is strongly and nearly regularly arched; the mesial sinus originates near the mid-length of the shell, it is abruptly depressed, its surface is nearly straight or slightly convex transversely across the bottom and is strongly curved towards the opposite valve longitudinally, anteriorly it is produced into a broad, elongate, lingual extension which lies in nearly a right angle to the plane of the valve, its greatest width is equal to about one-half the total width of the valve; the beak is small and moderately incurved; the delthyrium is nearly filled by the beak of the other valve, the deltidial plates and foramen are obscure and have not been observed in the specimens studied; the plications are sharply angular and originate at the beak, three or four occupy the bottom of the sinus, these being a little less angular than those upon the lateral slopes, each lateral slope bears from six to eight plications which become successively fainter towards the

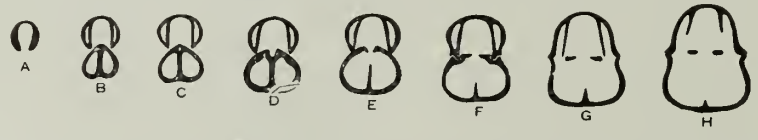

Fig. 5.—A series of eight cross-sections of the rostral portion of the shell of *Camarotœchia choutcauensis* (× 2½), showing the characters of the median septum, crural cavity, hinge-plate, and crura of the brachial valve, and the dental lamellæ of the pedicle valve.

cardinal margin, the last two or sometimes three being almost obsolete. Internally, the hinge-teeth are supported by short, dental lamellæ which scarcely extend beyond the articulation of the hinge.

Brachial valve gibbous, the greatest depth at or near the anterior margin, the surface sloping from the anterior margin to the beak along the median line with a convex curvature which is a little flattened in the middle portion, the umbonal region flattened transversely with a distinct longitudinal median depression which continues anteriorly for about one-fourth the length of the valve; the median fold not differentiated in the posterior half of the valve, flattened or gently convex on top and only moderately elevated above the lateral slopes anteriorly; lateral slopes strongly convex longitudinally and curving abruptly to the margin of the shell laterally; the beak strongly incurved beneath that of the opposite valve; plications similar in form and number to those of the opposite valve, those of the lateral slopes strongly arched longitudinally. Internally no cardinal process is present, the hinge-plate is divided and is supported towards the beak by a divided median septum which forms a crural cavity, the support of the hinge-plate by the divided median septum is discontinued posterior to the articulation of the hinge, but the free septum continues for about one-third the length of the valve, gradually becoming lower until it disappears.

A few obscure concentric lines of growth are sometimes present, but the shell is usually smooth aside from the plications.

Remarks.—This little shell is a common form in the fauna of the Chouteau limestone and may be easily recognized by its size and angular plications. It differs from *Rhynchopora? cooperensis* of the same fauna in its smaller size, relatively narrower shell and smaller number of plications on the fold and sinus.

Horizon.—Chouteau limestone.

Camarotœchia elegantula Rowley

Plate XXIV, Figs. 1-8

1900. *Camarotœchia elegantula* Rowley, Am. Geol., vol. 25, p. 264, pl. 5, figs. 44-47.

Description.—Shell small, broader than long, the postero-lateral margins nearly straight or slightly concave and meeting at the beak in an angle of from 90 to 110 degrees, the antero-lateral and anterior margins rounded. The dimensions of three nearly complete specimens are: length of pedicle valve 7.5 mm., 9.5 mm., and 8.5 mm.; length of brachial valve 7 mm., 8.5 mm., and 7.6 mm.; greatest width 8.3 mm., 11.6 mm. and 9.4 mm.; thickness 5.1 mm., 6.7 mm., and 6 mm.; width of sinus in front 6 mm., 8 mm., and 5.9 mm.

Pedicle valve convex in the umbonal region, the surface curving abruptly to the postero-lateral margins and sloping with a gently convex curvature to the antero-lateral margins or sometimes becoming a little concave as it approaches the margin, from beak to front along the median line the curvature of the surface is nearly a semicircle; mesial sinus originating near the middle of the valve, of only moderate depth, nearly flat, or sometimes gently convex across the bottom transversely, produced anteriorly in a rather broadly rounded or truncate lingual extension, the beak sharply pointed and incurved, obscuring the delthyrium. Surface marked by sharply angular, simple plications which originate at the beak, there being from four to six on the bottom of the sinus and about five on each lateral slope of the valve, the largest plications of the valve are those bounding the sinus, those of the lateral slopes growing rapidly smaller, the last one towards the cardinal extremities being very faint or almost obsolete. Internally the dental lamellæ are of moderate length and but slightly diverging anterior.

Brachial valve more convex than the pedicle, the greatest depth near the anterior margin, posteriorly from the point of greatest convexity the surface slopes with a very gently convex curvature which becomes rapidly more convex in the posterior half of the distance, anteriorly from the same point the curvature is short and abrupt, laterally the surface curves rather abruptly to the margins from the median portion of the valve which is gently convex transversely; mesial fold originating near the middle of the valve, not conspicuously differentiated from the general convexity except towards the anterior margin; beak pointed and strongly incurved beneath that of the opposite valve. Surface marked by simple plications similar to those of the opposite valve but a little less angular. Internally a median septum reaches anteriorly from the beak for about one-third the length of the valve, this septum divides internally in the manner characteristic of the genus, forming a crural cavity between the margins of the divided hinge-plate.

Minute surface markings obscure upon the specimen studied.

Remarks.—The above description of this species has been prepared from specimens collected by Professor Rowley from the original locality and identified by him as being members of his species, specimens which are, therefore, metatypes. The species is characterized by a width greater than its length, its angular plications, and the variable number of plications in the sinus. It differs from *C. tuta*, which is associated with it at the type locality, in its greater proportional width, its more angular plications, and the greater depth of the sinus in front.

Horizon.—Lower Burlington limestone (white chert.)

Camarotœchia tuta (Miller)

Plate XXIV, Figs. 9-28

1881. *Rhynchonella tuta* Miller, Jour. Cinn. Soc. Nat. Hist., vol. 4, p. 315, pl. 7, figs. 11-11b.

Description.—Shell small, length and width subequal or somewhat longer than wide, subovate in outline, the greatest width near or a little anterior to the mid-length, the postero-lateral margins nearly straight, sometimes a little concave or a little convex, the antero-lateral and anterior margins rounded or the anterior margin somewhat truncated. The dimensions of a nearly complete specimen from the type locality are: length of pedicle valve 6.4 mm., length of brachial valve 5.7 mm., greatest width 6.3 mm., thickness 4.5 mm., width of sinus in front 4.1 mm. The dimensions of a specimen from the Burlington white chert at Louisiana, Missouri, are: length of pedicle valve 7.3 mm., length of brachial valve 6.7 mm., greatest width 7.5 mm., thickness 5 mm., width of sinus in front 4.3 mm.

Pedicle valve convex in the umbonal region, the surface curving abruptly to the postero-lateral margins, gently convex from the umbonal region to the antero-lateral margins and arched in a subsemicircular curve along the mesial line from beak to front, with the posterior curvature a little more abrupt than the anterior; mesial sinus originating near the mid-length of the valve, nearly flat in the bottom transversely, produced anteriorly in a rather broadly rounded or subrectangular lingual extension; beak small, pointed, strongly incurved, coming nearly in contact with the umbo of the opposite valve, the delthyrium and deltidial plates obscured by the incurvature of the beak; plications simple, originating at the beak, rounded, becoming subangular towards the front, four usually if not always occupying the sinus, with about five upon each lateral slope which become successively smaller towards the cardinal extremities; concentric markings obscure or obsolete. Internally the dental plates are delicate and of moderate length, and are not widely divergent anteriorly from the beak.

Brachial valve more strongly convex than the pedicle, the greatest convexity anterior to the middle, sometimes near the front margin, the surface arched from the beak to the front along the median line, usually with the curvature more pronounced posteriorly, the curvature more convex to the antero-lateral margins, becoming abrupt to the postero-lateral margins; mesial fold originating near the mid-length of the valve, not strongly differentiated from the general curvature of the valve except close to the anterior margin, in the umbonal region a shallow, longitudinal, broadly subangular, mesial depression is present, which is deepest at the beak and becomes obsolete before the point of origin

of the mesial fold; the beak strongly incurved beneath that of the opposite valve; the plications similar in form and number to those of the opposite valve and alternate with them, the concentric markings also similar to those of the opposite valve.

Remarks.—This is a small species which was originally described from New Mexico and the above description has been drawn up from specimens collected at the type locality. Examples of the same species seem to be present in the Chouteau limestone of Missouri and Illinois, at least no characters have been detected which seem to be of sufficient importance to differentiate the two forms, although the Chouteau limestone examples seem to be somewhat more rotund and have slightly less angular plications anteriorly in the sinus.

Horizon.—Chouteau limestone and lower Burlington limestone.

Camarotechia sublogosa n. sp.

Plate XXIV, Figs. 29-33

Description.—Shell small, subglobose in form, the outline subovate, the length greater than the width, the greatest width near the mid-length of the shell. The dimensions of a nearly perfect internal cast are: length of pedicle valve 12.5 mm., length of brachial valve 10.7 mm., greatest width 10.8 mm., thickness 9 mm., width of sinus in front 5.9 mm.

Pedicle valve strongly convex, the greatest convexity near the middle, the surface curving abruptly to the postero-lateral margins, less abruptly to the antero-lateral and more gently to the anterior margin; mesial sinus originating near or a little back of the middle of the valve, only slightly depressed below the general surface, nearly flat transversely across the bottom, produced anteriorly in a rather short and broad mesial extension; beak rather prominent in the internal casts and only moderately incurved; plications simple, subangular, probably extending to the beak upon the external surface but becoming faint and obsolete towards the beak on the internal cast, three are present in the sinus and seven or eight upon each lateral slope, the last two or three towards the cardinal extremities becoming faint and at last nearly obsolete; rather crowded, fine, concentric lines of growth are present upon the internal cast over at least the anterior half of the valve, with an occasional stronger one, and upon the external surface these markings were doubtless strongly developed over the entire surface of the valve. Internally the dental plates are rather strong and of moderate length and between them is a well defined muscle scar which extends anteriorly for about one-third the length of the valve.

Brachial valve subcircular in outline, but little more convex than the pedicle, its greatest convexity near the middle, the surface describing

nearly a subsemicircular curve along the median line from the beak to the front, and curving rather abruptly to the lateral margins; mesial fold originating near the middle of the valve, only a little elevated above the general surface towards the front; the beak pointed and incurved beneath that of the opposite valve; the plications and concentric markings similar in form and number to those of the opposite valve. Internally a strong median septum extends anteriorly from the beak nearly or quite to the center of the valve, in the rostral portion of the valve this septum divides internally forming a short crural cavity between the two lateral portions of the divided hinge-plate.

Remarks.—This species has only been observed in the form of internal casts from the residual Burlington chert of Knox County, Missouri, it may be easily recognized by its subglobose form, its rather coarse plications and its shallow mesial sinus and low fold.

Formation.—Burlington limestone (residual chert).

CAMAROTŒCHIA MUTATA (Hall)

Plate XXIV, Figs. 41-60

1856. *Rhynchonella mutata* Hall, Trans. Albany Inst., vol. 4, p. 10.
1858. *Rhynchonella mutata* Hall, Geol. Iowa, vol. 1, pt. 2, p. 658, pl. 23, figs. 2a-b.
1882. *Rhynchonella mutata* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 52, pl. 6, figs. 43-45.
1883 *Rhynchonella mutata* Hall, 12th Rep. Geol. Surv. Ind., p. 332, pl. 29, figs. 43-45.
1894. *Rhynchonella mutata* Keyes, Mo. Geol. Surv., vol. 5, p. 103.
1895. *Pugnax mutatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 18-22.
1906. *Pugnax mutata* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1306, pl. 22, figs. 43-45.

Description.—Shell subovate or subtriangular in outline, usually wider than long, the greatest width in front of the mid-length of the shell, the postero-lateral margins straight or nearly straight, meeting at the beak in an angle of from 80 to 100 degrees, the anterior margin truncate, the antero-lateral margins more or less sharply rounded. The dimensions of two individuals are: length 9.7 mm. and 8.9 mm., width 10.6 mm and 9.1 mm., thickness 7 mm. and 5.5 mm., width of sinus in front 7.8 mm. and 5.8 mm.

Pedicle valve convex in the umbonal region, usually somewhat flattened in the middle and towards the antero-lateral margins, the surface curves rather abruptly to the postero-lateral margins, gently to the antero-lateral margins and is arched from the beak to the front; along the postero-lateral margins towards the beak, the edge of the valve is inflected to form a more or less indistinct pseudo-cardinal area, this area becoming less distinct in the older shells; mesial sinus obsolete in the posterior half of the

shell, anteriorly it is broad and shallow, its surface is curved towards the opposite valve, and its anterior margin is produced more or less conspicuously beyond the lateral margins; the beak is pointed, only slightly incurved and is produced posteriorly beyond that of the opposite valve; the delthyrium is broadly triangular and is partially closed by deltidial plates, with a subcircular foramen at the apex; plications simple, subangular, becoming faint or obsolete close to the beak, fourteen to twenty in number, from three to six of which occupy the median sinus, the first two or three on each side nearest the postero-lateral margins are very faint. Internally the teeth are supported by short dental lamellæ which do not continue anteriorly beyond the articulation of the hinge.

Brachial valve more strongly convex than the pedicle, the greatest depth anterior to the middle and in adult shells near the anterior margin; from the point of greatest convexity the surface curves more or less abruptly to the anterior margin and more gently to the posterior extremity, laterally the surface curves somewhat abruptly to the postero-lateral margins, but the median portion of the valve is somewhat flattened transversely; mesial fold scarcely defined except upon the more or less abrupt anterior slope of the valve and even there it is scarcely differentiated from the remainder of the valve; the beak strongly incurved beneath that of the opposite valve; plications similar in form and number to those of the opposite valve. Internally no cardinal process is present, the hinge-plate is longitudinally divided to the apex of the beak and in the extreme posterior portion of the valve it is supported by a median septum which is divided above, each division of the hinge-plate being supported by one limb; the divided median septum with its crural cavity between the divisions of the hinge-plate is extremely short and disappears posterior to the dental sockets, anteriorly the median septum is free and is reduced rapidly in height to a slight ridge along the bottom of the valve which sometimes continues for one-half the length of the valve; the divided hinge-plate becomes nearly horizontal anteriorly where its anterior extremity is produced into the crura.

The surface of both valves, aside from the plications, is nearly or quite smooth save for a few rather inconspicuous lines of growth near the anterior margin of adult shells.

Remarks.—This species is one of the abundant forms in the fauna of the Salem limestone. It was originally described from near Alton, Illinois, and in some of the Salem limestone localities in the bluffs above that city, it is particularly abundant. It is a variable shell, the variations being exhibited in the dimensions, convexity of the valves, fold and sinus, and number of plications. It differs from *C. grosvenori,* which occurs commonly in the same fauna in Indiana, in its larger size, stronger and more angular plications and less globular form.

The species has sometimes been referred to the genus *Pugnax,* but such reference is incorrect. Besides being quite different from typical members of that genus in external characters it possesses a crural cavity supported by a median septum at the base of the divided hinge-plate a character which is typical of the genus *Camarotœchia.*

Horizon.—Salem limestone.

Camarotœchia grosvenori (Hall)

Plate XXIV, Figs. 61-72

1856. *Rhynchonella Grosvenori* Hall, Trans. Albany Inst., vol. 4, p. 10.
1882. *Rhynchonella Grosvenori* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 53, pl. 6, figs. 31-34.
1883. *Rhynchonella grosvenori* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 331, pl. 29, figs. 31-34.
1895. *Pugnax Grosvenori* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 13-17.
1901. *Wilsonia Grosvenori* Whitfield and Hovey, Bull. Am. Mus. Nat. Hist., vol. 11, p. 388.
1906. *Pugnax grosvenori* Beede, 30th Ann Rep Geol. Surv. Ind., p. 1305, pl. 22, figs. 31-34.
1910. *Wilsonia grosvenori* Weller, Bull. Geol. Soc. Am., vol. 21, p. 510, fig. 11.

Description.—Shell small, subglobular in form, the width equal to, greater than or less than the length, the greatest width near or in front of the mid-length, the postero-lateral margins gently convex or nearly straight, meeting at the beak in an angle of 90 degrees or less, the anterior and antero-lateral margins more or less regularly rounded. The dimensions of a large individual are: length 7 mm., width 6.5 mm., thickness 5.5 mm., width of sinus in front 4.5 mm.

Pedicle valve more or less regularly convex throughout, the surface curving somewhat more abruptly to the postero-lateral margins, arched from beak to front; for a short distance on each side of the beak the edge of the valve along the postero-lateral margins is somewhat abruptly and sharply inflected to form a small pseudo-cardinal area; mesial sinus obsolete in the posterior half of the shell and sometimes obsolete throughout, usually it is broad and slightly depressed anteriorly and is produced anteriorly in a broad lingual extension which is curved towards the opposite valve to such an extent that its surface lies at nearly a right angle to the general plane of the valve in front; beak pointed, a little incurved and projecting posteriorly beyond the hinge-line; delthyrium broadly triangular, partially closed by deltidial plates, with a subcircular foramen at the apex which encroaches to some extent upon the beak of the valve; plications simple, rounded, from 18 to 22 in number, two or three of which on each side near the cardinal margins are very small, from three to six are included in the mesial sinus, four or five being the more usual num-

bers. Internally the teeth are supported by a pair of short dental plates which become obsolete anterior to the articulation of the hinge.

Brachial valve more convex than the pedicle, the greatest depth anterior to the middle and sometimes close to the anterior margin, from the point of greatest convexity the surface curves more or less gently to the posterior extremity, transversely the surface is rather regularly convex but it curves a little more abruptly as it approaches the lateral margins; mesial fold obsolete posteriorly and scarcely or not at all differentiated on the more or less abrupt anterior slope of the valve; the beak incurved beneath that of the opposite valve; plications similar in character and number to those of the opposite valve. Internally the hinge-plate is divided to its base and the cardinal process is lacking, at the extreme posterior apex of the valve a median septum is present, which is divided above to support the two limbs of the hinge-plate forming a crural cavity, this

FIG. 6.—A series of five cross-sections of the rostral portion of the shell of *Camarotœchia grosvenori* (× 2½), showing the dental lamellæ in the pedicle valve and the short median septum and small crural cavity in the brachial valve.

cavity disappears posterior to the articulation of the hinge and the median septum is rapidly reduced in height, although it frequently persists as a slight median ridge to the middle of the valve.

Aside from the plications the surface of both valves is nearly or quite smooth except in fully grown shells which have a few, distinct, parallel lines of growth close to the margin.

Remarks.—This species occurs commonly in the Salem limestone fauna in Indiana, but in the Illinois localities it is a rare shell. It resembles somewhat closely some of the variations of *C. mutata,* and in most large collections of the latter species a few individuals may usually be selected which by themselves might be referred to *C. grosvenori.* Typical representatives of the two species, however, are quite distinct. *C. grosvenori* is a smaller species, much more globular in form, with a much less well developed sinus in the pedicle valve, and with finer and less angular plications. Many and perhaps a majority of examples of *C. grosvenori* are longer than wide, while all but a very few specimens of *C. mutata* are wider than long.

Most recent writers have referred this species to the genus *Pugnax,* but a careful examination of the internal characters shows such reference to be incorrect. With the small crural cavity between the bases of the divided hinge-plate, supported by a median septum, the species must be excluded from the genus *Pugnax.*

The species has sometimes been referred to *Wilsonia,* but it differs from members of that genus in the absence of longitudinal, median grooves upon the plications as they approach the anterior margin.

Horizon.—Salem limestone.

Genus *LIORHYNCHUS* Hall

Description.—Shell usually of about medium size, subovate in outline and often subglobular in form. Mesial fold and sinus well developed, the plications obsolete or nearly obsolete upon the lateral slopes of the valves, more or less well developed on the fold and sinus. Internal characters of both valves as in *Camarotœchia.*

Remarks.—This genus has its greatest development in the Devonian faunas, but a few species are known in the Mississippian. The distinguishing characteristic of the genus is found in the condition of development of the plications, in combination with the median septum and crural cavity of the rostral portion of the brachial valve.

Liorhynchus greenianum (Ulrich)

Plate XXV, Figs. 27-33

1886. *Rhynchonella greeniana* Ulrich, Cont. to Am. Pal., No. 1, p. 26, pl. 3, figs, 1-1d.
1895. *Liorhynchus Greenianus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, p. 194.
1895. *Pugnax Greenianus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 36-38.
1910. *Leiorhynchus greencanum* Weller, Bull. Geol. Soc. Am., vol. 21, p. 511, fig. 12.

Description.—Shell of medium size or a little larger, subglobular in form, width usually a little greater than the length, the greatest width near the mid-length of the shell, the postero-lateral margins meeting at the beak in a rounded obtuse angle, the lateral margins rounded, the anterior margin usually broadly emarginate. The dimensions of a nearly complete specimen are: length 28.5 mm. width 28 mm., thickness 24.2 mm.

Pedicle valve convex in the umbonal region, the surface nearly flat from just in front of the umbo towards the antero-lateral margins in a broadly V-shaped region, from each limb of this V-shaped region the surface curves abruptly to the postero-lateral margins on the outside and more gently into the sinus internally, from the beak to the front along the median line the surface is arched to form nearly a semicircle; the mesial sinus originating near the middle of the valve as a broad, shallow, gently concave depression which becomes much deeper anteriorly; it is not sharply defined laterally and is produced in front in a broad, lingual extension, rounded in front and usually concave transversely, and whose

surface anteriorly lies in nearly a right angle to the plane of the valve; beak rather blunt and short, incurved and nearly in contact with the umbo of the opposite valve, the delthyrium apparently broadly triangular and nearly filled by the beak of the opposite valve, the deltidial plates and foramen obscure and not observed in any of the specimens studied; plications almost obsolete, limited to from two to four, all of which are present in the anterior part of the sinus, having their origin near or in front of the middle of the valve. Internally the hinge-teeth are supported by a pair of short dental plates which scarcely extend beyond the articulation of the hinge.,

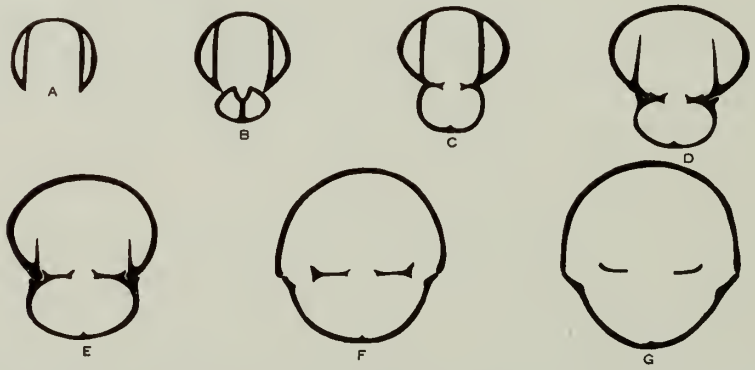

FIG. 7.—A series of seven cross-sections of the rostral portion of the shell of *Liorhynchus greenianum* (× 2½), showing the dental lamellæ in the pedicle valve and the median septum and crural cavity in the brachial valve.

Brachial valve gibbous, its convexity much greater than that of the pedicle valve, the surface strongly arched from beak to front along the median line with an increasing curvature towards the beak, laterally from the median line the surface curves abruptly to the margins, the curvature usually being a little broken towards the front by the differentiation of the mesial fold; the mesial fold obsolete in the posterior half of the valve, usually but not always slightly differentiated anteriorly; the beak strongly incurved beneath that of the opposite valve; the plications similar to those of the opposite valve and restricted to the anterior portion of the mesial fold. Internally the cardinal process is wanting and the hinge-plate is divided; at the apex of the valve a divided median septum is present, one side of which supports each side of the divided hinge-plate at its initial point, the space between the two divisions forming a crural cavity which, however, is very short and terminates before the articulation of the hinge is reached, beyond the crural cavity the septum is rapidly reduced in height and continues anteriorly for from one-fourth to one-third of the length of the valve as a faint ridge.

The minute surface markings of the shell are preserved in none of the specimens studied, but concentric lines of growth, irregular in strength and distribution, are present upon all specimens examined.

Remarks.—In its external form this species most closely resembles *Shumardella obsolens*, but it always grows to a much larger size and may be recognized by that character alone. Internally the two forms are quite distinct, *L. greenianum* having the hinge plate of the brachial valve completely divided, with the space between the two divisions of the median septum much broader, and the septum reduced in height much more rapidly. Both the internal characters and the external form agree with the genus *Liorhynchus*, in which genus the species is placed unhesitatingly.

Horizon.—Knobstone formation, Indiana.

Genus *PARYPHORHYNCHUS* Weller

Description.—Shells rhynchonelliform, of medium size or larger, subovate to transversely subrhomboidal in outline, mesial fold and sinus well developed, both valves marked by broad, rounded plications, which reach nearly or quite to the beak, surface of both valves also marked by fine, radiating striæ which cover both the plications and the intervening furrows. The internal characters of the rostral portion of both valves entirely similar to *Camarotœchia*.

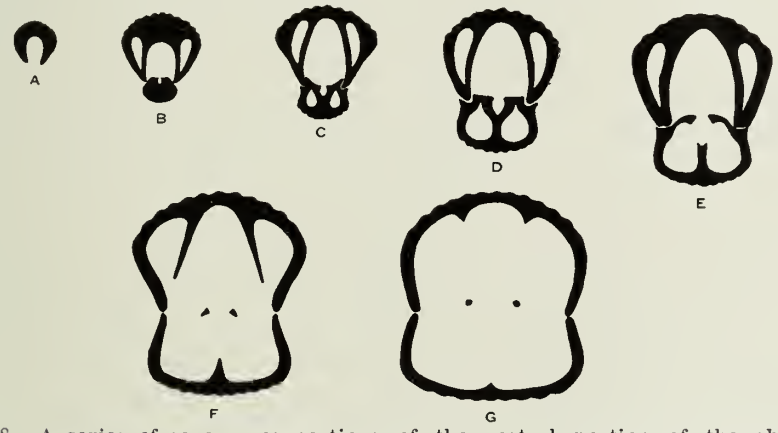

FIG. 8.—A series of seven cross-sections of the rostral portion of the shell of *Paryphorhynchus elongatum* (× 2½), showing the dental lamellæ of the pedicle valve and the median septum, crural cavity and crura of the brachial valve.

Remarks.—In the arrangement of the internal structures of the rostral portion of the shell in this genus, there is nothing to differentiate it from *Camarotœchia*. The essential generic features are found in the external characters, viz., the broad plications and especially in the finely striate shell surface, in association with the camarotœchoid interior.

Paryphorhynchus transversum Weller

Plate XXVI, Figs. 23-28

1895. *Pugnax missouriensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 62, figs. 44-45. (Not *Rhynchonella missouriensis* Shumard, 1855.)
1900. *Pugnax striatocostata* var.? Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 72, pl. 2, figs. 16-17.
1905. *Paraphorhynchus transversum* Weller, Trans. St. Louis Acad. Sci., vol. 15, p. 264, pl. 1, figs. 12-15.

Description.—Shell of medium size, wider than long, transversely subelliptical in outline, the greatest width near the mid-length, the postero-lateral margins nearly straight and meeting at the beak in an obtuse angle, the lateral and antero-lateral margins rounded, the anterior margin gently convex. The dimensions of a nearly complete internal cast are: length 25 mm., width 31 mm., thickness 23 mm., width of sinus in front 19.5 mm.

Pedicle valve flattened back of the umbo, the surface curving rather abruptly to the postero-lateral margin and usually incurved to some extent, to the antero-lateral margins the surface is gently convex, and to the front it is strongly arched; the mesial sinus originates in or near the umbonal region and becomes rapidly deeper towards the front; it is deeply concave anteriorly and is produced in a rounded lingual extension in front; the beak is obtusely pointed and rather sharply incurved; the plications are broad, subangular or rounded on top with furrows of about equal width separating them, three or more, usually four, are included in the sinus with about four upon each lateral slope of the valve, sometimes the lateral plications of the sinus become obsolete towards the front. Internally the teeth are supported by a pair of diverging dental lamellæ which extend anteriorly from the beak for about one-fourth the length of the valve.

Brachial valve much more convex than the pedicle, the greatest convexity at or near the anterior margin, the surface sloping from the front to the beak along the median line with a gradually increasing curvature, posteriorly the surface curves abruptly towards the postero-lateral margins and is slightly inflected, forming with the narrower incurved portion of the opposite valve a lateral concave region on each side of the beak; mesial fold not differentiated in the umbonal region, at first gradually and then more strongly elevated towards the front, convex on top with rather steep sides, its width in front equal to nearly half the width of the shell; the lateral slopes curving strongly towards the opposite valve both laterally and anteriorly; the beak strongly incurved beneath that of the opposite valve; the plications are similar in form and number to those of the opposite valve, sometimes the two lateral plications of the fold coalesce with the next inner ones towards the front. Internally

there is no cardinal process, the hinge-plate is divided to the base and its initial portion is supported by a divided median septum forming a crural cavity at the base of the divided hinge-plate, the median septum continues with gradually decreasing height for about one-fourth the length of the valve from the beak.

In addition to the plications the surface is marked by fine radiating striæ, about four of which occupy the space of one millimeter, and by concentric lines of growth which are irregular in strength and distribution but usually become more conspicuous anteriorly.

Remarks.—This species, so far as known, is restricted in its distribution to some of the fine yellow sandstone formations in the Kinderhook at Burlington, Iowa; Washington County, Iowa; and Kinderhook, Illinois. It is most closely allied to *P. striaticostatum*, but it attains a larger size than that species and is proportionally much wider with a more obtuse beak. Some of the young individuals have more the outline of *P. striaticostatum*, but as they increase in age they become more transverse.

Horizon.—Chonopectus sandstone of the Kinderhook.

Paryphorhynchus striaticostatum (Meek and Worthen)

Plate XXVI, Figs. 15-22

1868. *Rhynchonella Missouriensis* Meek and Worthen, Geol. Surv. Ill., vol. 3, p. 450, pl. 14, figs. 7a-d.
1868. *Rhynchonella striatocostata* Meek and Worthen, Geol. Surv. Ill., vol. 3, p. 452.
1895. *Pugnax striato-costata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, p. 204.
1895. *Pugnax missouriensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 33-34.
1901. *Pugnax striatocostata* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 154, pl. 13, figs. 14-16.
1905. *Paraphorhynchus striatocostatum* Weller, Trans. St. Louis Acad. Sci., vol. 15, p. 262, pl. 1, figs. 6-11.

Description.—Shell of about medium size, broadly subovate or subtriangular in outline, the width usually greater than the length, the greatest width near or anterior to the mid-length, the postero-lateral margins slightly convex or nearly straight, meeting at the beak in an angle of from 80 to 100 degrees, the antero-lateral and anterior margins regularly rounded or with the anterior margin sometimes straightened. The dimensions of a nearly perfect specimen are: length 25 mm., width 26 mm., thickness 17.8 mm., width of sinus in front 18 mm.

Pedicle valve shallow, the surface flattened towards the umbo, curving abruptly to the postero-lateral margins and sometimes becoming somewhat inflected, curving gently to the antero-lateral margins and strongly arched from beak to front; mesial sinus originating on or close to the umbonal region, becoming deep and broad anteriorly, rounded in the bottom

and produced in front in a broad, rounded, lingual extension whose surface at the front of adult shells lies in nearly a right angle to the plane of the valve; beak small, pointed, incurved so as to be almost in contact with the umbo of the opposite valve in full grown specimens, pierced at the apex by a very small subcircular foramen; delthyrium broadly triangular, nearly filled by the beak of the opposite valve, the deltidial plates inconspicuous; plications coarse and strong, rounded, with furrows of about equal width between, three or four plications are usually present in the bottom of the broad sinus and three or four upon each lateral slope, making from nine to twelve upon the entire valve, the one nearest the postero-lateral margin on each side usually being faint or obscure. Internally the teeth are supported by a pair of dental lamellæ which diverge anteriorly and continue for about one-fifth of the length of the valve.

Brachial valve much more convex than the pedicle, the greatest depth at or near the anterior margin, the surface sloping with a gradually increasing curvature from the anterior margin to the beak, from the median line the surface curves abruptly to the postero-lateral margins and towards the beak is sometimes a little inflected as it approaches the margin to form, with a similar inflected portion of the opposite valve, an ill-defined, slightly concave, lateral area on each side of the valve, in the anterior portion of the valve the surface passes from the median line with an abrupt double curvature, first to the border of the mesial fold and then to the lateral margins of the valve; the mesial fold is ill-defined posteriorly but originates back of the middle of the valve and is strongly elevated in front where it is broad and rounded on top; the beak is strongly incurved beneath that of the opposite valve, the plications correspond in form and number to those of the opposite valve with which they alternate. Internally there is no cardinal process and the hinge-plate is divided to the base, being supported in its initial portion by a median septum which divides to form a crural cavity between the two divisions of the hinge-plate as in the genus *Camarotœchia.*

In addition to the plications the surface of both valves is marked by fine, radiating, longitudinal striæ, about four or five of which occupy the space of one millimeter and by fine concentric lines of growth. On some examples stronger lines of growth are sometimes present at intervals.

Remarks.—This species can be easily distinguished from the other membeers of the genus *Paryphorhynchus,* by its smaller size and somewhat intermediate character, it being distinctly shorter than *P. elongatum* and narrower than *P. transversum.* The species occurs most commonly in bed No. 4 of the Kinderhook section at Burlington, Iowa, and in a Kinderhook limestone near Kinderhook, Pike County, Illinois. The recorded occurrence of the species in the Louisiana limestone of Missouri is probably an error.

Horizon.—Kinderhook.

PARYPHORHYNCHUS ELONGATUM Weller

Plate XXVI, Figs. 10-14

1905. *Paraphorhynchus elongatum* Weller, Trans. St. Louis Acad. Sci., vol. 15, p. 216, pl. 1, figs. 1-5.

Description.—Shell of medium size or larger, subovate in outline, longer than wide, the greatest width anterior to the middle, the postero-lateral margins nearly straight or gently convex and meeting at the beak in an acute angle of from 70 to 85 degrees, the anterior and antero-lateral margins rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 37 mm., length of brachial valve 34.7 mm., width 28.8 mm., thickness 22.5 mm., width of sinus in front 23.8 mm.

Pedicle valve strongly convex, the greatest convexity near or posterior to the middle, posteriorly the surface is regularly convex transversely in the central portion of the valve, but as it approaches the lateral margins it curves rather abruptly towards the opposite valve and is then continued in a nearly vertical or slightly inflected direction to the edge, from the beak to the front the surface describes nearly a semicircle in full grown shells, but to the antero-lateral margins the curvature is not so great; the mesial sinus originates near the middle of the valve and is formed rather by the elevation of the borders above the general surface of the valve than by the distinct depression of the sinus itself, it is broad and is gently convex transversely across the depressed portion, anteriorly it is produced as a broad, rounded, lingual extension whose surface at the extreme margin lies at nearly a right angle to the general plane of the valve; the lateral slopes are narrow and are abruptly elevated from the bottom of the sinus in front; the beak is small, sharply pointed, closely incurved and nearly in contact with the umbo of the opposite valve; the delthyrium is broadly triangular and is nearly filled by the beak of the opposite valve, neither the deltidial plates nor the foramen has been observed, but both must be inconspicuous; the plications originate near the beak and are broad and rounded on top with rounded furrows of about equal width between, they are from ten to fourteen in number, four or five of which occupy the sinus, the outermost plication of the sinus on each side frequently becomes obsolete before it reaches the anterior margin. Internally the teeth are supported by a pair of strong dental lamellæ which may extend anteriorly from the beak from one-fifth to one-fourth the length of the valve. Upon the casts of the interior of the valve well defined but delicate pallial sinuses are clearly shown.

Brachial valve equally or a little more convex than the pedicle, the greatest depth at or near the anterior margin, the surface curving from the anterior margin to the beak, along the median line, with a gradually increasing curvature which becomes rather abrupt near the beak; in the

median portion of the valve, posteriorly, the surface is regularly convex transversely, but near the postero-lateral margins it curves rather abruptly towards the opposite valve and then continues in a nearly vertical direction to the margin where it meets the similar vertical surface of the opposite valve and forms the lateral flattened or slightly concave region which is present each side of the beak; the mesial fold is obsolete in the umbonal region, is gradually elevated anteriorly to near the front margin where the elevation becomes abrupt, or rather the lateral slopes are curved abruptly towards the opposite valve, the fold is sharply defined and is nearly flat or slightly convex transversely across the top with abruptly descending sides; the lateral slopes of the valve are narrow, their surface curves gently from the sides of the fold towards the lateral margins for a short distance and then curves abruptly towards the opposite valve; the beak is incurved strongly beneath that of the opposite valve; the plications are similar in form and number to those of the opposite valve, one or more pairs upon the fold sometimes coalescing as they approach the anterior margin. Internally no cardinal process is present and the hinge-plate is divided to the base, each division being supported by one side of a crural cavity which is joined to the floor of the valve by a median septum, the crural cavity continues to a point opposite the articulation of the hinge, beyond which the median septum becomes rapidly lower, the cura extend forward into the cavity of the shell from the anterior margin of the hinge-plate.

In addition to the plications the surface of each valve is marked by fine radiating striæ, four or five of which occupy the space of one millimeter, and by still finer concentric striæ with stronger lines of growth at intervals.

Remarks.—In some of its aspects this species resembles the elongate, coarsely plicated shells of *Rhynchotetra caput-testudinis* with its flattened lateral areas on each side of the beak, but it is smaller than that species and more distinctly striated longitudinally besides possessing an entirely different internal structure, there being no median septum and spondylium in the pedicle valve. The species differs from *P. striaticostatum* in its larger size, more elongate form, more convex valves and the more conspicuous, lateral, flattened areas on each side of the beak.

Horizon.—Kinderhook.

Genus *PUGNOIDES* Weller

Description.—Shells rhynchonelliform, below medium size, subovate in outline, with the fold and sinus well developed. Both valves marked by rounded or subangular plications which become obsolete in the posterior portion of the shell. Internal characters of both valves essentially as in *Camarotœchia.*

Remarks.—This genus approaches more closely to *Camarotœchia* than any of those here considered, having camarotœchoid interiors, although the genotype has usually been included in *Pugnax,* in which no median septum or crural cavity is developed in the rostral portion of the brachial valve. The members of this genus agree with *Camarotœchia* in general size, and form, as well as in internal characters, being distinguished from that genus by the obsolescence of the plications towards the beak, in which character they are like *Pugnax.*

Pugnoides ottumwa (White)

Plate XXV, Figs. 7-17

1862. *Rhynchonella Ottumwa* White, Proc. Bost. Soc. Nat. Hist., vol. 9, p. 23.
1880. *Rhynchonella ottumwa* White, Cont. to Inv. Pal., No. 8, p. 165, pl. 41, figs. 5a-c.
1894. *Rhynchonella ottumwa* Keyes, Mo. Geol. Surv., vol. 5, p. 103.
1895. *Pugnax Ottumwa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, figs. 23-26.
1910. *Pugnoides ottumwa* Weller, Bull. Geol. Soc. Am., vol. 21, p. 512, fig. 13.

Description.—Shell below medium size, suboval to subpentagonal in outline, usually wider than long, the greatest width usually anterior to the mid-length of the shell. The dimensions of two individuals are: length 12 mm. and 10.7 mm., width 12.5 mm. and 11.3 mm., thickness 8 mm. and 6.3 mm.

Pedicle valve with rather long, nearly straight postero-lateral margins which meet at the beak in an acute angle, the lateral and anterior margins rounded, the surface convex in the umbonal region, curving abruptly to the postero-lateral margins, less abruptly to the anterior margin and only gently convex or nearly straight to the antero-lateral margins; along

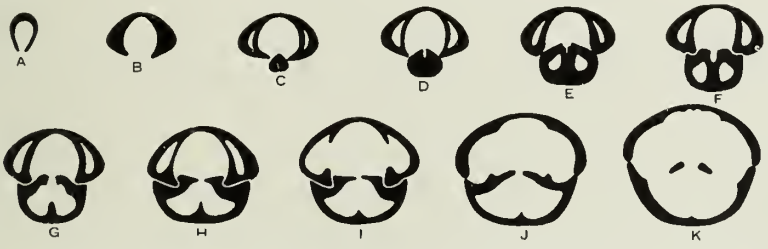

Fig. 9.—A series of eleven cross-sections of the rostral portion of the shell of *Pugnoides ottumwa* (× 2½), showing the dental lamellæ of the pedicle valve and the median septum, crural cavity and crura of the brachial valve.

the postero-lateral margins towards the beak, the edge of the valve is abruptly inflected to form a sort of false cardinal area; mesial sinus obso-

lete in the posterior half of the valve, becoming rather broad and deep anteriorly and somewhat produced in front in a linguiform extension which curves strongly towards the opposite valve; the beak acutely pointed, only a little incurved, produced posteriorly beyond the brachial valve to a conspicuous degree; delthyrium large and triangular, partially closed by a pseudo-deltidium, with a large, subelliptical foramen; plications simple, obsolete towards the beak but originating in or near the umbonal region, gradually increasing in strength until they become conspicuously subangular towards the margin, usually two or three are present in the bottom of the sinus, more rarely one, four or five, upon each lateral slope there are usually three but sometimes only two strong plications, with from one to four additional weaker ones towards the cardinal margin. Internally the teeth are supported by a pair of short dental plates.

Brachial valve more convex than the pedicle, the greatest convexity near the middle, from the center of the valve the surface curves most abruptly to the postero-lateral margins, more gently to the posterior extremity and to the antero-lateral margins, and extends nearly horizontally to the anterior margin; mesial fold obsolete posteriorly, becoming somewhat strongly elevated in front; the beak incurved beneath that of the opposite valve; plications entirely similar to those of the opposite valve, three or four usually present on the fold but sometimes two or five, two or three strong ones on each lateral slope, and several weaker ones. Internally the valve bears a median septum which is somewhat rapidly reduced in elevation in passing from the beak anteriorly, becoming entirely obsolete in about one-third or less the length of the valve, posteriorly the septum is divided to form a crural cavity which does not continue anteriorly beyond the hinge sockets, each side of the divided septum is produced anteriorly into one of the lateral divisions of the hinge plate, and these in turn are produced into the somewhat elongate crura which curve towards the pedicle valve.

Surface of both valves usually quite smooth aside from the plications, except near the margin of adult shells where there may be several more or less distinct lines of growth, sometimes a more or less distinct line of growth is present in the umbonal region and when present it usually marks the place of origin of the plications.

Remarks.—This shell is usually a prolific species wherever it is found. It occurs most abundantly in the Pella beds of Iowa, but is also a conspicuous species in some of the Ste. Genevieve beds of Illinois. The species may be easily recognized by its smooth shell, aside from the plications, by the conspicuously protuberant beak of the pedicle valve, and by the inflected cardinal margin of the pedicle valve to form a false cardinal area.

The species has been referred to the genus *Pugnax* by Hall and Clarke, but the internal structure of the brachial valve is that of *Camarotœchia* rather than *Pugnax*. The specimen figured by these authors as the brachial valve of the species with its broadly divided hinge-plate unsupported by a median septum, must be either incomplete or it must be something else. Repeated sections of authentic examples from Pella, Iowa, show the camerotœchoid characters here described and illustrated.

Horizon.—Ste. Genevieve limestone.

Pugnoides boonensis (Shumard)

Plate XXV, Figs. 22-26

1855. *Rhynchonella Boonensis* Shumard, Geol. Rep. Mo., p. 205, pl. C, figs. 6a-b.
1894. *Rhynchonella boonensis* Keyes, Mo. Geol. Surv., vol. 5, p. 101.
1895. *Leiorhynchus (?) Boonensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 60, fig. 35.

Description.—Shell of about medium size, broadly ovate-subtriangular in outline, wider than long, the greatest width near the mid-length, the postero-lateral margins nearly straight and meeting in an obtuse angle, the antero-lateral margins rounded, the anterior margin sinuate. The dimensions of a nearly perfect specimen are: length of pedicle valve 19.1 mm., length of brachial valve 17.9 mm., greatest width 24 mm., thickness 17 mm., width of mesial sinus of pedicle valve in front 17 mm.

Pedicle valve gently convex in the umbonal region, flattened towards the antero-lateral margins, strongly arched from beak to front along the median line, the curve forming nearly a semicircle, narrowly but rather abruptly curved along the postero-lateral margins and a little inflected to the cardinal extremities; mesial sinus originating near the mid length of the valve, becoming broad and rather deep anteriorly and produced in a broadly rounded lingual extension whose surface lies at nearly a right angle to the plane of the valve; the beak obtusely pointed and only a little incurved; plications obsolete upon the posterior portion of the valve, but a little developed in front of the middle, those of the sinus, two in number, originating near the mid-length of the valve, rounded on top and becoming stronger towards the anterior margin, on one or both sides of this pair of strong plications there is sometimes a much fainter plication initiated near the margin; on each side of the mesial sinus upon the lateral slopes one or two faint plications are commonly present which are limited to the extreme margin of the valve. Internally the dental lamellæ are short, between them in the rostral portion of the valve is a short, low, median ridge, but anteriorly, beyond the extremities of the lamellæ the inner surface of the valve is somewhat excavated for the muscular attachment.

Brachial valve strongly convex transversely and moderately convex from the beak to near the front along the median line, the greatest convexity of the valve near the front margin, the anterior slope very short and curving somewhat abruptly to the anterior margin; mesial fold not differentiated from the general convexity except towards the anterior margin, and even there the differentiation is not conspicuous; the beak pointed and incurved beneath the beak of the opposite valve; three short but rather strong plications are present anteriorly upon the mesial fold, and one or two fainter and even shorter ones upon each lateral slope,

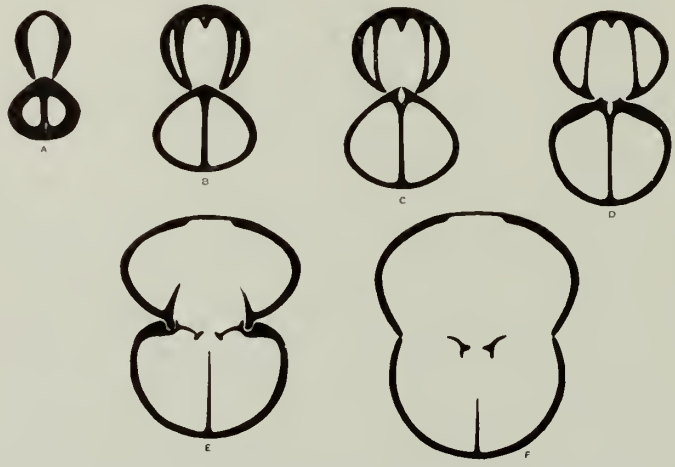

FIG. 10.—A series of six cross-sections of the rostral portion of the shell of *Pugnoides boonensis* (× 2½), showing the dental lamellæ and slight median septum of the pedicle valve, and the median septum, the small crural cavity and the crura of the brachial valve.

the greater portion of the valve posteriorly entirely non-plicate. Internally a well developed median septum is present which extends anteriorly upon the interior surface of the valve for more than one-third the length of the valve, in the rostral portion of the valve the median septum is divided internally to form a crural cavity such as is present in this genus, the crural cavity is very short and terminates posterior to the articulations of the valves, the crural bases joined to the hinge-plate for a short distance beyond the termination of the crural cavity.

Surface of both valves marked by fine, obscure, but rather regular, concentric lines of growth, with an occasional stronger and more or less conspicuous one; radiating striæ not present.

Remarks.—This species approaches the European *Pugnax pugnus* more nearly in its external form than any other of our American Mississippian rhynchonelloids, but the internal characters of the shell differentiate it

from the genus *Pugnax* and bring it in conformity with the members of the genus *Pugnoides* which possess the median septum in the brachial vave and the erural cavty between the opposite parts of the divided hinge-plate. The species is one of the rarest forms in the lower Burlington limestone.

Horizon.—Fern Glen formation, lower Burlington limestone.

Genus *ALLORHYNCHUS* Weller

Description.—Shells rhynchonelliform, small or below medium size, with mesial fold and sinus well developed and both valves marked by subangular or rounded plieations which are usually well defined to the beak. Interior of the pedicle valve with slender dental lamellæ. In the brachial valve the hinge-plate is divided, the inner edges of each lateral portion being unsupported, no median septum and no erural cavity, sueh as is present in *Camarotœchia* are developed.

Remarks.—In external features the members of this genus are not essentially different from *Camarotœchia,* but an examination of the interior of the rostral portion of the braehial valve shows that they are not at all alike. In the entire absence of lamellæ of any sort for the support of the hinge-plate of the braehial valve, *Allorhynchus* is like *Pugnax,* but it differs from that genus in the eompletely plicated shell.

Allorhynchus heteropsis (Winehell)

Plate XXIV, Figs. 73-81

1865. *Rhynchonella heteropsis* Win., Proc. Aead. Nat. Sei. Phil., p. 121.
1901. *Camarotocchia (?) heteropsis* Weller, Trans. St. Louis Aead. Sci., vol. 11, p. 156, pl. 13, figs. 9-13.
1910. *Allorhynchus heteropsis* Weller, Bull. Geol. Soc. Am., vol. 21, p. 509, fig. 8.

Description.—Shell small, triangularly subovate in outline, usually wider than long, the greatest width anterior to the mid-length of the shell, the postero-lateral margins nearly straight or a little sigmoidal and meeting at the beak in an angle from 90 to 108 degrees, the antero-lateral margins rounded and the anterior margin straight or convex. The dimensions of two individuals are: length 11.1 mm. and 12 mm., width 13.6 mm. and 12 mm., thickness 7.5 mm. and 6.4 mm., width of sinus in front 9.3 mm. and 7 mm.

Pedicle valve convex on the umbo, the surfaee eurving rather abruptly to the cardinal margin with the edges of the valve narrowly infleeted for a short distance on each side of the beak, towards the antero-lateral margins the surfaee is gently convex or flattened and from the beak to the front margin it is rather strongly arehed; the sinus originates near

or a little back of the middle of the valve and becomes rapidly deeper anteriorly and is moderately produced in a broad, rounded extension in front, where its width is about one-half the total width of the shell; it is usually nearly flat across the bottom in front with the sides sloping outward or rarely nearly vertical; the beak is acuminate and sharply pointed and is strongly incurved, coming nearly in contact with the umbo of the opposite valve; the delthyrium is nearly filled by the beak of the opposite valve, the deltidial plates and foramen are obscure and have not been clearly recognized in any of the specimens studied; the plications are simple, angular, rather coarse, and originate at the beak, three or rarely four occupy the bottom of the sinus with sometimes an additional one upon each sloping side, with from four to six upon each lateral slope of the valve, the plications of the lateral slopes nearest the margins of the sinus are the strongest and most angular ones on the valve. Internally the hinge-teeth are weak and are supported by a pair of short, thin, dental lamellæ.

FIG. 11.—A series of six cross-sections of the rostral portion of the shell of *Allorhynchus heteropsis* (× 2½), showing the presence of dental lamellæ in the pedicle valve and the entire absence of lamellæ in the brachial valve.

Brachial valve much more convex than the pedicle, its greatest convexity at or near the front margin, the surface slopes along the median portion of the shell from the front margin to the beak with a regular or with an increasing curvature, at the umbo the surface is impressed along the median line in a shallow but distinct sinus which continues to the middle of the valve either as a distinct sinus or as a flattened surface, to the postero-lateral margns the surface slopes first with a convex curvature and then becomes flattened or sometimes even concave; the mesial fold is scarcely distinct back of the middle of the valve but anteriorly it is rather strongly and abruptly elevated above the lateral slopes; the lateral slopes are convex with the surface curving rather strongly both anteriorly and laterally; the beak strongly incurved beneath that of the opposite valve; the plications are similar in form and number to those of the opposite valve. Internally the hinge-plate is divided to its base and lacks supporting septa of any kind, the cardinal process and median septum wanting.

Remarks.—In its usual condition of preservation the surface of this species is exfoliated so that all indication of minute surface markings is destroyed, but upon remnants of the shell which are sometimes present

extremely fine, crowded concentric striæ can be detected. Occasionally stronger lines of growth are present, but they are never conspicuous.

Horizon.—Kinderhook.

Allorhynchus macra (Hall)

Plate XXV, Figs. 1-6

1856. *Rhynchonella macra* Hall, Trans. Albany Inst., vol. 4, p. 11.
1856. *Rhynchonella ricinula* Hall, Trans. Albany Inst., vol. 4, p. 9.
1882. *Rhynchonella macra* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 52, pl. 6, figs. 40-42.
1882. *Rynchonella ricinula* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 53, pl. 6, fig. 46.
1883. *Rynchonella macra* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 334 pl. 29, figs. 40-42.
1883. *Rynchonella ricinula* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 330, pl. 29, fig. 46.
1906. *Rhynchonella macra* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1307, pl. 22, figs. 40-42.
1906. *Rynchonella ricinula* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1308, pl. 22, fig. 46.
1910. *Allorhynchus macra* Weller, Bull. Geol. Soc. Am., vol 21, p. 509, fig. 9.

Description.—Shell small, compressed, subovate to subtriangular in outline, usually a little wider than long but sometimes longer than wide, especially in small or young individuals, the greatest width anterior to the middle, the postero-lateral margins gently convex or nearly straight and usually meeting at the beak in an angle of less than 90 degrees, the antero-lateral and anterior margins regularly rounded or with the anterior margin sometimes straightened. The dimensions of two individuals are: length 6.5 mm. and 5.5 mm., width 7.1 mm. and 6 mm., thickness 3 mm. and 2.7 mm., width of sinus in front 4.5 mm. and 3.1 mm.

Pedicle valve most convex posterior to the middle, the surface gently arched from beak to front and also transversely along the line of greatest width, but posteriorly the curvature to the lateral margins is more abrupt, towards the beak the edge of the shell along the postero-lateral margins is abruptly and sharply inflected to form a rather conspicuous pseudo-cardinal area; mesial sinus entirely obsolete posteriorly where it is replaced by a slight mesial elevation which is not differentiated laterally from the lateral slopes of the valve, towards the front the mesial portion of the valve is somewhat flattened and is rarely slightly depressed in a broad, shallow, ill-defined sinus; the beak is pointed, scarcely incurved and is produced posteriorly rather conspicuously in a nearly horizontal direction; the delthyrium is broadly triangular and is partially closed by deltidial plates which are pierced at the apex by a subelliptical foramen which encroaches to some extent upon the beak of the valve;

plications simple, rounded, 14 to 22 in number, two or three of which on each side adjacent to the postero-cardinal margins are very faint, they are obsolete at the beak but originate in the umbonal region, usually at the first strong concentric line of growth. Internally the hinge-teeth are supported by a pair of short dental lamella which do not extend anteriorly beyond the articulation of the hinge.

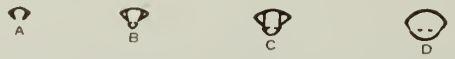

FIG. 12.—A series of four cross-sections of the rostral portion of the shell of *Allorhynchus macra* (× 2½), showing the dental lamellæ of the pedicle valve and the absence of lamellæ in the brachial valve.

Brachial valve equally or a little less convex than the pedicle, the greatest convexity posterior to the middle, anteriorly the surface curves gently to the anterior and antero-lateral margins; posteriorly the surface first curves gently from the median line laterally and then rather abruptly as it approaches the postero-lateral margins; mesial fold obsolete; in younger specimens and in the older part of mature ones there is a distinct but slight depression along the median line which continues to the front of full grown examples as a broad mesial flattening which is not sharply differentiated from the lateral slopes of the valve; the beak is rather sharply incurved beneath that of the opposite valve; the plications are entirely similar in form and number to those of the opposite valve. Internally the hinge-plate is divided to the base and no median septum is present, anteriorly the two divisions of the hinge-plate are produced as crura.

The surface of both valves, in addition to the plications, is marked by exceedingly fine concentric striæ and by several stronger lines of growth which are sometimes placed at nearly regular intervals throughout the entire length of the shell, the plications commonly originate at the first of the lines of growth in front of the beak.

Remarks.—This species may be easily recognized by its small size and much compressed shell. The smaller examples may sometimes resemble the young of the associated *Camarotœchia mutata,* but that species is apt to have a more pronounced sinus in the anterior margin of the pedicle valve, and the internal characters of the two species are different, the median septum of the brachial valve with its crural cavity supporting the bases of the divided hinge-plate being absent in the present species. *Rhynchonella ricinula* Hall, seems to be only the young of the larger *R. macra,* and is so considered here, although Whitfield states that mature examples of *R. macra* do not occur with *R. ricinula.* In the collections from the Salem limestone above Alton, Illinois, the typical locality for *R. macra,* small examples which seem to agree fully with the figures

of *R. ricinula* are not infrequent, and their association is such as to indicate that they are without doubt the young of the larger examples which more typically represent *R. macra*. These two names were both proposed by Hall in the same paper, and as *ricinula* occurs on an earlier page it might be given priority by some, but as no injustice can be done by adopting *macra* it seems best to do so since that name was applied to the mature and more normal form of the species.

Horizon.—Salem limestone.

ALLORHYNCHUS ACUTIPLICATUM n. sp.

Plate XXIV, Figs. 83-86

Description.—Shell small, broadly subovate in outline, broader than long, the greatest width anterior to the mid-length of the shell, the postero-lateral margins nearly straight and meeting at the beak in an angle of about 90 degrees or a little more, the antero-lateral margins rounded, the anterior margin usually nearly straight but sometimes slightly sinuate or a little convex. The dimensions of a perfect specimen are: length of pedicle valve 10.9 mm., length of brachial valve 9.8 mm., greatest width 12.7 mm., thickness 7.2 mm., width of sinus in front 6.9 mm.

Pedicle valve convex in the umbonal region, the surface curving abruptly to the postero-lateral margins and a little inflected to the cardinal extremities, from the umbo to the antero-lateral margins the surface is gently convex and from the beak to the anterior margin along the median line it is arched with the strongest curvature anteriorly; the mesial sinus originates near the middle of the valve and becomes rapidly deeper towards the front, where it is a little produced in a broadly rounded extension, its surface is nearly flat transversely in the bottom, with the sides sloping outward; the beak is sharply pointed and only a little incurved, being produced posteriorly conspicuously beyond the incurved beak of the opposite valve, with its apex somewhat remote from the umbo of the opposite valve; the delthyrium broadly triangular, only its basal part filled by the beak of the opposite valve, the remaining portion closed by the deltidial plates which are sometimes destroyed in the fossils; the plications simple, fine and subangular towards the beak, becoming acutely angular towards the front margin, four usually occupying the sinus, all of which may be included in the bottom of the depression or one may be crowded up a little way upon one of the lateral surfaces, from eight to ten occupy each lateral slope of the valve, growing successively smaller towards the cardinal extremities, the last three or four becoming very faint and sometimes nearly obsolete; the concentric markings of the valve are obscure or nearly obsolete, consisting of a few faint lines of growth which are commonly present near the margin of the valve. Internally the dental plates are well developed and extend one-fourth or a little more of the length of the valve anteriorly from the beak.

Brachial valve more convex than the pedicle, its greatest convexity near or in front of the middle, the surface curving in nearly a quadrant of a circle from the point of greatest convexity to the beak, with a much gentler curvature to the anterior margin; in the umbonal region the surface is flattened medially and curves abruptly to the postero-lateral margins, from the beak to the antero-lateral margins the curvature of the surface is nearly a semicircle; the mesial fold originating in front of the middle, of only moderate height at the front margin; the beak strongly incurved beneath that of the opposite valve; the plications are similar in form and number to those of the opposite valve, there being five on the mesial fold and from seven to ten on each lateral slope, towards the outer margin the plications are sharply angular, alternating with those of the opposite valve, and giving to the line of junction between the two valves a strongly zig-zag direction along the anterior and antero-lateral margins; concentric markings similar to those of the opposite valve. Internally the hinge-plate is divided to the apex of the valve and is entirely unsupported, the cardinal process, median septum, and crural cavity wanting.

Remarks.—This species differs from *A. heteropsis,* the genotype, in its finer and more numerous plications, a larger number of which occupy the fold and sinus, in the more arched brachial valve from beak to front, in the less incurved beak of the pedicle valve, and usually in the greater proportional width of the shell.

Locality.—Webb City, Mo. (?Carterville formation).

Genus *PUGNAX* Hall and Clarke

Description.—Shell rhynchonelliform, variable in size, the mesial fold and sinus well developed, the sinus sometimes much produced in front, the valves more or less sharply plicated with simple plications, those of the fold and sinus usually the stronger and all becoming obsolete in the posterior portion of the shell, pedicle valve shallow and brachial valve deep. Internally the hinge-teeth of the pedicle valve are supported by well developed dental lamellæ. In the brachial valve the hinge-plate is divided, the two portions being unsupported by any lamellæ whatsoever, no median septum or cardinal process present.

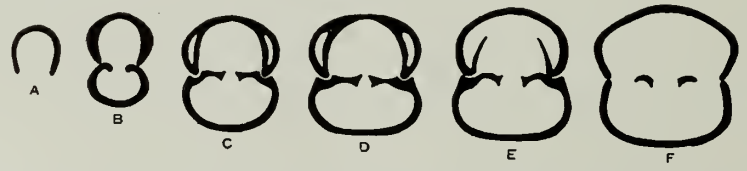

Fig. 13.—A series of six cross-sections of the rostral portion of the shell of *Pugnax pugnus* (× 2½), showing the dental lamellæ of the pedicle valve and the entire absence of lamellæ in the brachial valve.

Remarks.—Several species from our Mississippian and Devonian faunas, which possess internal structures of the rostral portion of the brachial valve entirely like those of *Camarotachia* and not at all agreeing with the genotype of *Pugnax,* have been referred commonly to the genus *Pugnax.* With the removal of these species to the new genus *Pugnoides,* the genus *Pugnax* itself is left with very meager representation in our faunas, and of the two species here recognized the typical internal characters have been observed in only one.

Pugnax wortheni (Hall)

Plate XXV, Figs. 37-42

1856. *Rhynchonella Wortheni* Hall, Trans. Albany Inst., vol. 4, p. 11.
1882. *Camarophoria Wortheni* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 54, pl. 6, figs. 35-39.
1883. *Camarophoria (?) wortheni* Hall, 12th Rep. Geol. Surv. Ind., p. 334, pl. 29, figs. 35-39.
1906. *Camarophoria wortheni* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1305, pl. 22, figs. 35-39.

Description.—Shell small, subovate in outline, the length and breadth subequal or the width greater than the length, the greatest width near or anterior to the mid-length of the shell. The dimensions of two individuals, the smaller one a young example, are: length 7 mm. and 4.5 mm., width 7.4 mm. and 4.5 mm., thickness 5.3 mm. and 2.9 mm.

Pedicle valve gently convex in the umbonal region, flattened towards the antero-lateral margins, and deeply sinuate in front, the edge of the valve along the postero-lateral margins towards the beak is inflected to form a narrow, pseudo-cardinal area; the sinus originates near the middle of the valve, is rapidly depressed, and in adult shells is produced in front as a linguiform extension whose surface lies at nearly a right angle to the plane of the valve; the beak is pointed, scarcely incurved and is produced conspicuously beyond that of the opposite valve; the plications originate near the middle of the shell, and become rapidly stronger as they approach the margin, one or two rounded ones occupying the bottom of the sinus and about two, rarely more, more subangular ones occupying each lateral slope of the valve. Internally a pair of diverging dental lamellæ extend a short distance forward from the beak.

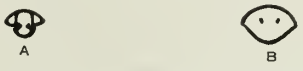

Fig. 14.—A series of two cross-sections of the rostral portion of the shell of *Pugnax wortheni* (× 2½), showing the dental lamellæ of the pedicle valve and the entire absence of lamellæ in the brachial valve.

Brachial valve more convex than the pedicle, becoming gibbous in front in full grown shells, the surface sloping from a point at or near the anterior margin with a more or less gentle convexity to the beak, the lateral slopes of the valve rather strongly convex from the beak to the front; mesial fold strongly elevated in front; beak incurved beneath that of the opposite valve; the plications similar to those of the opposite valve, two or three occupying the mesial fold, with about two or three upon each lateral slope.

The surface of the shell marked by minute concentric lines of growth, and in adult shells by a few, more or less irregular, stronger ones towards the front margin.

Remarks.—This species was referred to the genus *Camarophoria* by Whitfield, and all later writers have followed him in this reference. Authentic specimens, however from Hull's Hollow, above Alton, which is, or is very near, the typical locality for the species, show that the dental lamellæ of the pedicle valve continue separately to the bottom of the valve and are not united to form a spondylium supported by a median septum as is true in *Camarophoria*. Furthermore, the rostral cavity of the brachial valve is entirely lacking in lamellæ of any sort, there being no median septum, and no crural cavity, the internal characters of both valves being exactly as in typical representatives of the genus *Pugnax*.

Horizon.—Salem limestone.

Pugnax quadrirostris Beede

Plate XXV, Figs. 34-36

1906. *Pugnax ? quadrirostris* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1306, pl. 19, figs. 4-4e.

Description.—Shell very small, subquadrangular in outline, the length and breadth subequal, the greatest width near the middle of the shell. The dimensions of a nearly perfect specimen are: length 3 mm., width 3.4 mm., thickness 2 mm.

Pedicle valve convex in the umbonal region, the surface curving abruptly from the umbonal region to the postero-lateral margins, transversely between the points of greatest lateral extension the surface is nearly flat, anteriorly the valve curves strongly towards the opposite valve and is produced into a broad, elongate, lingual extension whose length in the specimen observed is more than one-half the total length of the valve; mesial sinus originating near the beak as a narrow, rather obscure, slightly impressed furrow, anteriorly it merges into the broad, shallow mesial depression which extends nearly to the lateral extremities of the valve and includes the entire lingual extension; beak short, a little incurved; the delthyrium nearly closed by the beak of the opposite valve;

plications low and obscure, originating in front of the umbonal region, eight or ten may be detected in the specimen studied, all of which are included within the broad median sinus, the two median plications are the broadest, the others being much narrower.

Brachial valve strongly convex transversely, the surface along the median line describing a slightly sigmoidal curve, being a little convex posteriorly and becoming slightly concave towards the front, from the median line the surface curves steeply to either side, the least abrupt curvature being towards the points of greatest lateral extension near the mid-length of the valve; mesial fold obscure posteriorly but in front of the middle it includes nearly the entire width of the valve; beak small, incurved beneath that of the opposite valve and nearly filling the delthyrium of that valve; plications obscure, similar to those of the opposite valve.

Surface of both valves marked by exceedingly fine concentric lines of growth.

Remarks.—Only a single example of this species, from Bloomington, Indiana, has come under the observation of the writer but this specimen is apparently more perfect than either of those figured by Beede. At first sight the shell seems to be entirely free from plications but a careful examination discloses them as they have been described. Material is not at hand for the investigation of the internal features of the shell, but in all of its external aspects it more closely resembles such typical members of the genus *Pugnax* as *P. acuminatus*, than any other form which has been referred to that genus from our Mississippian faunas. In most respects, in fact, the shell is only an extremely minute example of *P. acuminatus*.

Horizon.—Salem limestone.

Genus *RHYNCHOTETRA* Weller

Description.—Shells usually of about medium size or larger, subovate to triangularly subovate in outline, often subcuneate posteriorly, the valves subequally convex or the brachial valve more convex than the pedicle, the mesial fold and sinus slightly developed or obsolete. Both valves marked by broad, rounded or subangular plications which are either simple or dividing, and when the surface is well preserved it is also marked by fine, radiating striæ; upon the postero-lateral surfaces of the shell the plications become obsolete or nearly so. Internally the dental lamellæ of the pedicle valve are strongly developed, becoming joined near the floor of the valve to form a broad and deep spondylium which is supported by a strong median septum and which continues anteriorly towards the center of the valve. In the rostral portion of the brachial valve a strong median septum is present which divides internally to form the walls of a deep and rather narrow crural cavity, posteriorly the hinge-

plate is undivided so that the crural cavity is closed internally, but anteriorly the hinge-plate is divided and the crural cavity is open as in *Camarotœchia*, but the borders of the cavity are extended beyond the hinge-plate and are somewhat convergent so that the opening into the crural cavity is narrowed and slit-like. The crura are formed by the anterior extension of the inner margins of the two portions of the divided

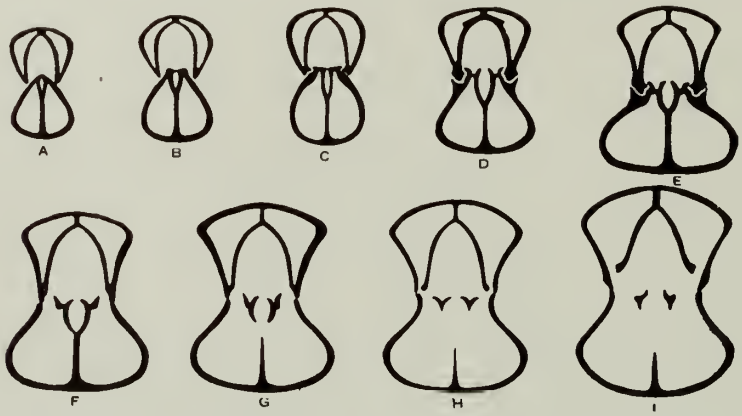

FIG. 15.—A series of nine cross-sections of the rostral portion of the shell of *Rhynchotetra missouriensis* (× 2½), showing the dental lamellæ of the pedicle valve joined to form a spondylium supported by a median septum; and the median septum, crural cavity, and crura of the brachial valve.

hinge-plate and the adjacent portions of the walls of the crural cavity, and the median septum is extended conspicuously along the floor of the valve beyond the anterior margin of the crural cavity.

Remarks.—The members of this genus have sometimes been included in the pentameroid genus *Camarophoria* because of the presence of a distinct median septum in each valve, with the spondylium in the pedicle valve, but they lack entirely the cruralium in the brachial valve, which is so characteristically developed in that genus, between the hinge-plate and the floor of the valve. Some of the species have also been described as members of the genus *Paryphorhynchus* because of the fine radiating striæ upon the surface of the shell, but the internal structure of the two genera is entirely different.

RHYNCHOTETRA CAPUT-TESTUDINIS (White)

Plate XXVII, Figs. 1-6

1862. *Rhynchonella caput-testudinis* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 23.
1894. *Rhynchonella sp.* ? Keyes, Mo. Geol. Surv., vol. 5, pl. 41, fig. 11.
1901. *Camarophoria caput-testudinis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 196, pl. 19, figs. 1-4.

Description.—Shell above medium size, strongly plicated, subtriangular in outline, cuneate posteriorly, longer than wide, the greatest width anterior to the middle. The dimensions of the most perfect of the type specimens are: length of pedicle valve 42 mm., length of brachial valve 40 mm., greatest width 38.6 mm., thickness 27 mm., width of sinus in front 27.3 mm.

Pedicle valve arched from the beak to the front, the curvature becoming much more abrupt anteriorly, the surface gently convex transversely in the median portion of the valve, the gentle convexity extending to the lateral margins in the widest portion, the postero-lateral margins abruptly deflected towards the opposite valve, the deflected portion on each side forming one-half of a flattened or concave oval region which is present on each side of the beak, and upon which the plications are obscure; mesial sinus obscure, obsolete in the posterior half of the valve, becoming slightly depressed anteriorly and produced in a broad and rather long lingual extension; beak small, pointed, scarcely incurved; the plications strong, mostly simple, rounded or subangular on top, separated by broad rounded furrows of which from 16 to 18 are present upon the valve, about 6 or 7 occupying the mesial depression near the front of the valve. Internally the dental lamellæ are well developed and extend anteriorly from the beak for nearly one-third the length of the valve with only slight divergence, they each join the inner surface of the valve, not being united to form a spondylium elevated upon a median septum.

Brachial valve more convex than the pedicle, the greatest convexity towards the front, from this point of greatest convexity the surface slopes to the beak with a long, gentle convex curvature, becoming a little more abrupt near the beak, the anterior slope is much shorter, towards the antero-lateral margins the surface curves much more abruptly, and towards the postero-lateral margins it is abruptly deflected to meet the similar deflected portion of the opposite valve; mesial fold ill-defined and obscure, not elevated above the general surface of the valve in the posterior portion of the valve, but more distinctly elevated in front; beak pointed and incurved beneath that of the opposite valve; plications entirely similar to those of the opposite valve. Internally a median septum extends anteriorly from the beak for nearly one-third the length of the valve.

The finer surface markings consist of minute, radiating striæ, and exceedingly fine concentric markings, in addition to which are occasional stronger, concentric lines of growth, the finer markings usually being visable only with a lens.

Remarks.—This species is characterized by its nearly simple plications and its rather broad, triangularly subovate outline. The types of the species are three in number, one nearly complete example with both

valves present, from a fine grained, compact limestone which resembles, lithologically, bed No. 4 of the Kinderhook at Burlington, Iowa. The other two examples are from the porous brown limestone of bed No. 7 of the same section. In the original description the species is recorded from "the base of the Burlington Limestone," which, from a consideration of the specimens, should doubtless be interpreted as Kinderhook.

Girty[1] has figured a shell under the name *Camarophoria ringens* which is of the type of White's *Rhynchonella caput-testudinis*. This shell clearly has the outline suggested by the original definition of *R. ringens*, and similar specimens have not infrequently been identified with Swallow's species by collectors in the Mississippi Valley, although they commonly possess a smaller number of plications than Swallow designates. This type of shell can scarcely be considered as representative of Swallow's species, however, because no example of it has ever been observed by recent collectors in the cherts from which *R. ringens* is said to have been collected.

Horizon.—Kinderhook.

Rhynchotetra ovatum (Greger)

Plate XXVII, Figs. 16-20

1910. *Paraphorhynchus ovatum* Greger, Am. Jour. Sci. (4), vol. 29, p. 74, figs. 9-10.

Description.—Shell of medium size or somewhat larger, subovate in outline, longer than wide, the greatest width near the mid-length, the posterior extremity usually acutely pointed, the line of junction between the valves deeply and strongly serrate. The dimensions of a nearly perfect specimen, one of the cotypes, are: length of pedicle valve 35.5 mm., length of brachial valve 33.3 mm., greatest width 26.8 mm., thickness 18 mm.

Pedicle valve gently convex throughout the greater portion of its surface, its greatest depth near the middle, abruptly deflected towards the opposite valve near the postero-lateral margins, the deflected surface nearly flat and lying nearly at a right angle to the plane of the valves or slightly concave and somewhat inflected to the margin towards the cardinal extremities; mesial sinus obscure or essentially obsolete, when best developed it is broad, only slightly depressed, and restricted to the extreme anterior part of the valve; beak not prominent, pointed, only moderately incurved; surface of the valve marked by from sixteen to twenty, usually simple, strong but rather low, radiating plications, rounded on top and separated by rounded furrows, most of them originate near the beak, only rarely and upon some specimens never do they increase by division or implantation upon the body of the valve.

[1] Mon. U. S. Geol. Survey, vol. 33, pt. 2, pl. 69, figs. 1a-b (1889).

Brachial valve slightly deeper than the pedicle but similar in form, it is gently convex through the greater portion of its surface, being abruptly deflected towards the opposite valve near the postero-lateral margins, the deflected portion is a little broader than that of the opposite valve and is continuous with it, the two together forming the subovate, flattened or slightly concave lateral areas in the posterior portion of the shell; mesial fold obscure or obsolete, when best developed it is but slightly differentiated and is restricted to the extreme anterior portion of the valve; beak pointed, incurved beneath that of the opposite valve; plications similar in all respects to those of the opposite valve.

Surface of both valves, when well preserved, marked by fine, radiating striæ, about three or four of which occupy the space of one millimeter.

Remarks.—The internal characters of this species have not been fully investigated, but the strong dental lamellæ of the pedicle valve joining to form a spondylium-like cavity near the inner surface of the valve, are clearly visible in one example with the rostral portion of that valve broken, and in the brachial valve a well developed median septum is clearly seen upon the slightly weathered surface. There is no reason to doubt but that the arrangement of the internal lamellæ agrees essentially with that of *R. missouriensis*, which has been carefully sectioned. The species agrees most closely with *R. caput-testudinis*, but it is somewhat smaller, with much less convex valves, with a more subovate outline and somewhat finer plications. It is clearly distinct from *R. gibbosum* by reason of its less convex valves and its simple plications which usually originate near the beak and continue to the margin without additions by subdivision or intercalation.

Horizon.—Chouteau limestone.

Rhynchotetra elongatum n. sp.

Plate XXVIII, Figs. 9-12

Description.—Shell below medium size, longer than wide, the greatest width in front of the middle, the anterior portion of the shell subsemicircular in outline, the posterior portion acutely subcuneate. The dimensions of a nearly perfect individual are: length of pedicle valve 27.2 mm., length of brachial valve 26.5 mm., width 18 mm., thickness 8.5 mm.

Pedicle valve depressed convex, greatest convexity posterior to the middle, nearly flat anterior to the middle, the postero-lateral margins abruptly deflected towards the opposite valve, the deflected portion on each side forming one-half of a suboval, flattened or concave region on each side of the beak; mesial sinus essentially obsolete; beak small, pointed, scarcely incurved; the umbonal region with a median septum internally; plications nine or ten in number, those in the middle of the

shell strong, becoming much fainter towards the postero-lateral margins, mostly simple, and becoming obsolete near the beak where the umbonal region for a short distance is essentially nonplicate, the plications are subangular on top and are separated by broad furrows.

Brachial valve depressed convex, similar in form to the pedicle, the surface gently arched from the beak to the anterior and antero-lateral margins, not so much flattened anteriorly as the opposite valve, the postero-lateral margins abruptly deflected to meet the similar deflected portions of the opposite valve and to form a part of the subovate flattened regions on each side of the beak; mesial fold obsolete; beak small, pointed, incurved beneath that of the opposite valve; plications entirely similar to those of the opposite valve.

The minute surface markings consist of extremely fine, radiating striæ. Lines of growth of varying strength occur at intervals.

Remarks.—This shell is allied to *R. caput-testudinis*, but it differs from that species in its much smaller size and less convex valves. These characters might be interpreted as youthful characters, but the type specimen has all the appearances of being a mature shell. The species also differs from *R. gibbosum* in its smaller size and in the absence of the conspicuous divarication of the plications. It is perhaps most closely allied to *R. ovatum*, but it is narrower, much more elongate, and proportionally thinner.

Horizon.—Pierson limestone of the Kinderhook.

Rhynchotetra missouriensis n. sp.

Plate XXVIII, Figs. 1-8

Description.—Shell of about medium size, triangularly subovate in outline, longer than wide, the greatest width anterior to the middle, the postero-lateral margins nearly straight or a little concave, the antero-lateral margins rounded, the anterior margin gently convex or sometimes subtruncate. The dimensions of a nearly complete specimen are: length of pedicle valve 29 mm., length of brachial valve 27.5 mm., width 27 mm., thickness 15.7 mm.

Pedicle valve depressed convex, the surface gently and nearly regularly convex longitudinally from beak to front, and also transversely along the line of maximum width; along the postero-lateral margins the valve is abruptly deflected towards the opposite valve to form a minor portion of the suboval, flattened or somewhat concave, lateral regions lying upon each side of the beak; mesial sinus obsolete; beak small, pointed, only slightly incurved; plications broad, rounded, separated by rounded furrows about equal to the plications in width; about four or five plications originate at the beak, the two lateral ones each giving origin to three or four others from their outer sides, the median ones usually bifurcating

once near or in front of the middle, making twelve to fifteen plications in all upon the lateral and anterior margins; internally the dental lamellæ are strongly developed and are joined to form a spondylium supported by a median septum, as has been shown in the generic description.

Brachial valve more convex and deeper than the pediele, the greatest depth near the middle, the surface curving from the central point with a regular convexity in all direetions; along the postero-lateral margins the surface is abruptly deflected towards the opposite valve, the deflected portion forming the larger part of the flattened or concave areas on each side of the beak; mesial fold obsolete; the beak small, pointed, incurved beneath that of the opposite valve; the plications entirely similar to those of the opposite valve, but with the later ones added by intercalation rather than by division. Internally, a median septum is present whieh is divided internally to form a crural cavity, as has been shown in the generic description.

The minute surface markings eonsist of fine, radiating striæ. Lines of growth of varying strength may be present and are sometimes a little crowded towards the anterior margin.

Remarks.—This speeies most closely resembles *R. gibbosum*, but it is a much thinner speeies, with much less eonvex valves, and with the greatest width more anterior in position; in the form and arrangement of the plications, however, the two speeies are much alike.

Horizon.—Burlington limestone.

Rhynchotetra gibbosum (Greger)

Plate XXVII, Figs. 7-15

1894. *Rhynchonella* sp. (?) Keyes, Mo. Geol. Surv., vol. 5, pl. 41, fig. 8.
1910. *Paraphorhynchus gibbosum* Greger, Am. Jour. Sci. (4), vol. 29, p. 73, figs. 1-6.

Description.—Shell strongly plicate, of medium size or larger, longer than wide, the greatest width near or in front of the middle, the anterior outline usually subsemicircular, the posterior outline acutely subcuneate. The dimensions of a nearly complete specimen, a cotype, are: length 39 mm., width 25.5 mm., thickness 28 mm.

Pedicle valve arched from the beak to the front, but somewhat more flattened posteriorly, arched to the antero-lateral margins, the postero-lateral margins abruptly deflected towards the opposite valve, the deflected portion forming nearly one-half of an oval, flattened or concave lateral region upon each side of the shell; mesial sinus obsolete in the posterior portion of the shell, broad, shallow, obscure and ill-defined anteriorly; beak small, pointed, a little incurved; plications strong, rounded on top, separated by broad, rounded furrows, from three to five originate near the beak, all or nearly all of whieh divide at intervals

in passing from the beak to the front margin, the one on each side nearest to the postero-lateral deflection of the valve giving origin to four or more plications from its outer side which are arched across the oval, postero-lateral flattened portion of the valve.

Brachial valve more convex than the pedicle, arched from the beak to the anterior and antero-lateral margins, the greatest depth of the valve near the middle, the postero-lateral margins sharply deflected to meet the similar deflected portion of the opposite valve and helping to form the oval, flattened areas on each side the rostral portion of the shell; mesial fold obsolete posteriorly, obscure and poorly defined anteriorly; beak small, pointed, incurved beneath that of the opposite valve; plications similar to those of the opposite valve, but with the younger plications often added by intercalation instead of by bifurcation; at the postero-lateral margins plications similar to those of the opposite valve are arched across the deflected portion of the valve.

The minute surface markings of the shell consist of exceedingly fine radiating striæ which are crossed by fine concentric lines of growth. Stronger lines of growth are sometimes present at intervals, more especially towards the anterior margin.

Remarks.—In general form, size and proportions this species resembles *R. caput-testudinis,* but it differs from that species in being notably thicker and especially in the conspicuous and more or less frequent bifurcation or intercalation of plications; the presence of the strong plications which arch across the oval postero-lateral regions of the shell also distinguishes this species from *R. caput-testudinis.*

Horizon.—Burlington limestone.

Genus *TETRACAMERA* Weller

Description.—Shell rhynchonelliform, small or of medium size, triangularly subovate to subpentagonal in outline, the mesial fold and sinus poorly developed or nearly obsolete except towards the front, the lateral and anterior margins of both valves deflected so as to stand at nearly right angles to the plane of the valves, both valves marked by simple, subangular or rounded plications which reach to the beak. Internally the pedicle valve possesses strongly developed dental lamellæ which curve towards the median line as they approach the floor of the valve, and form a deep spondylium which rests upon the inner surface of the valve or is slightly raised on a median septum anteriorly, from the external surface of each dental lamella a transverse buttress plate extends across the intervening cavity to the inner surface of the outer shell wall. In the rostral portion of the brachial valve a strong median septum is present which is undivided at the apex of the valve, but before the articulation of the shell is reached a median incision is formed internally

which is at first arched over but soon becomes open internally by the incision between the lateral divisions of the divided hinge-plate, the crural cavity so formed being essentially identical with that of *Camarotœchia;* the cavities between the median septum and the outer shell walls are each divided by a lamella or septum resting upon the floor of the valve and supporting the inner margin of the corresponding lateral division of the hinge-plate, these lateral septa extending farther anteriorly than the median septum.

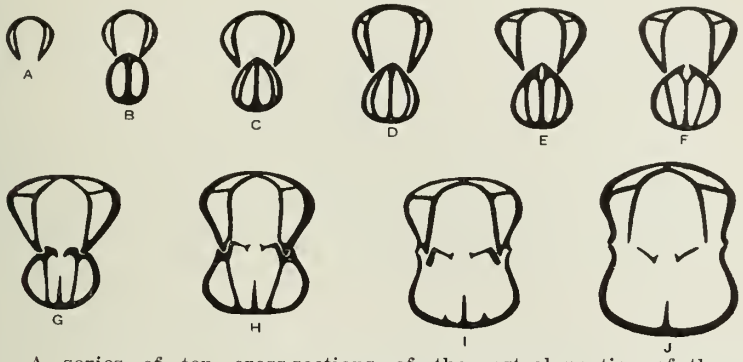

FIG. 16.—A series of ten cross-sections of the rostral portion of the shell of *Tetracamera subcuncata* (× 2½), showing the dental lamellæ and buttress plates of the pedicle valve, and the median and two lateral lamellæ, the crural cavity and crura of the brachial valve.

Remarks.—The species included in this genus were referred to *Camarophoria* by Hall and Clarke,[1] and usually have been so referred since the publication of their work. The shells do not possess the characteristic cruralium of *Camarophoria,* besides possessing other characters wholly foreign to that genus. The most essential generic characters are the presence of the buttress plates connecting the dental lamellæ with the inner surface of the outer shell wall, and the presence of the supplementary lamellæ in the rostral portion of the brachial valve in addition to the median septum. The species *T. subtrigona* which is here included in the genus differs in a rather fundamental manner from the genotype, not only in the general form of the shell but in the arrangement of the internal lamellæ, and should perhaps be made the type of a distinct genus, but the discussion of these characters is reserved for treatment under the specific description.

1 Pal. N. Y., vol. 8, pt. 2, p. 214 (1894).

Tetracamera subcuneata (Hall)

Plate XXVIII, Figs. 13-24

1856. *Rhynchonella subcuneata* Hall, Trans. Albany Inst., vol. 4, p. 11.
1858. *Rhynchonella subcuneata* Hall, Geol. Iowa, vol. 1, pt. 2, p. 658, pl. 23, figs. 3a-c.
1863. *Rhynchonella perrostellata* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 85.
1882. *Rhynchonella subcuneata* Whitf., Bull. Am. Mus. Nat. Hist., vol. 1, p. 51, pl. 6, figs. 47-49.
1883. *Rhynchonella subcuneata* Hall, 12th Rep. Geol. Surv. Ind., p. 333, pl. 29, figs. 47-49.
1894. *Camarophoria subcuneata* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 45, figs. 3-4.
1894. *Rhynchonella subcuneata* Keyes, Mo. Geol. Surv., vol. 5, p. 102.
1895. *Camarophoria subcuneata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 62, figs. 34-37.
1906. *Camarophoria subcuneata* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1304, pl. 22, figs. 47-49.
1910. *Tetracamera subcuneata* Weller, Bull. Geol. Soc. Am., vol. 21, p. 503, fig. 4.

Description.—Shell below medium size, the valves subequally convex, subtriangular in outline, usually broader than long, the greatest width near the anterior extremity, the long postero-lateral margins straight or a little concave, usually meeting at the beak in an acute angle. The dimensions of two examples are: length 11.7 mm. and 10.4 mm., width 12 mm. and 11.5 mm., thickness 7.3 mm. and 6.3 mm. The dimension of the largest example observed are: length 15.3 mm., width 15.3 mm., thickness 9.6 mm.

Pedicle valve depressed-convex, the surface gently arched from the beak to the anterior margin except in old shells in which the valve is rather abruptly deflected anteriorly to meet a similar deflection of the opposite valve, along the postero-lateral margin the valve is abruptly deflected towards the opposite valve, the deflected portion on each side forming about one-half of a smooth, flattened or slightly concave region on each side of the beak; mesial sinus obsolete posteriorly and represented anteriorly only as a slight, indefinite flattening of the valve which sometimes cannot be detected at all; beak small, sharply pointed, slightly incurved, the delthyrium triangular, open towards the apex but closed below by the beak of the opposite valve; plications angular, from 12 to 20 in number, either simple or dividing near the beak, in no case is the bifurcation upon the body of the shell a conspicuous feature.

Brachial valve similar in form to the pedicle, the surface arched from the beak to the anterior margin, the curvature being strongest near the beak, the postero-lateral margins deflected to meet the similar deflected portion of the opposite valve and to take part in the formation

of the flattened or concave lateral regions on each side of the beak; mesial fold obsolete; beak strongly incurved and partially filling the delthyrium of the opposite valve; plications entirely similar to those of the opposite valve.

The minute surface markings consist of fine, obscure, radiating striæ which are usually obsolete because of the condition of preservation of the shell surface, when preserved they can be best seen upon the flattened, postero-lateral portions of the shell. Fine concentric lines of growth are present when the shell is properly preserved, and are subimbricating in character, stronger lines of growth occur at irregular intervals. In old shells which are much flattened anteriorly by reason of the anterior deflection of the valves, and to a less extent in younger individuals, the margins of the valves are deeply incised by the interlocking serrations of the two valves, and parallel with the line of juncture and adjacent to it the lines of growth are usually conspicuously crowded.

Remarks.—This species is a highly characteristic member of the fauna of the Salem limestone. Its only close ally is *T. arctirostrata,* which is characterized by its larger size and by the presence of fine radiating striæ upon the surface of the shell.

Horizon.—Salem limestone.

Tetracamera arctirostrata (Swallow)

Plate XXVIII, Figs. 25-34

1863. *Rhynchonella arctirostrata* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 84.

1910. *Camarophoria arctirostrata* Greger, Am. Jour. Sci. (4), vol. 29, p. 73, figs. 11-12.

Description.—Shell below medium size, length and width sub-equal or somewhat wider than long, the greatest width in front of the middle, subtriangular in outline with the postero-lateral margins long and nearly straight, the antero-lateral margins rounded, the anterior margin somewhat truncated or slightly convex, the line of junction between the valves deeply and sharply serrate. The dimensions of a very perfect example are: length of pedicle valve 15.6 mm., length of brachial valve 14.8 mm., greatest width 15.4 mm., thickness 12.8 mm.

Pedicle valve gently convex throughout the greater portion of its surface and gently arched from the beak to near the front margin, towards the postero-lateral margins the valve is abruptly deflected to the margin, the deflected portion lying in nearly a right angle to the plane of the valve, antero-laterally the deflection is only a little less abrupt but anteriorly it is notably less, although this margin also curves towards the opposite valve until it lies nearly at right angles to the plane of the valve; mesial sinus obscure, sometimes nearly obsolete, when best developed it is broad and only slightly depressed and is restricted to the

anterior portion of the valve; beak acutely pointed and moderately incurved; plications sixteen to twenty in number, simple and reaching from the beak to the margins without intercalations, rounded posteriorly but becoming more or less subangular near the anterior and antero-lateral margins, those upon the postero-lateral deflections of the valve curving strongly towards the margin.

Brachial valve much deeper than the pedicle, its greatest depth near the anterior margin, gently convex along the median line from the point of greatest depth to the beak and curving abruptly from the same point to the anterior margin, gently convex transversely across the central portion of the valve and abruptly deflected laterally towards the opposite valve, postero-laterally the deflected portion is a little concave, becoming a little convex anteriorly, the deflected portion being much broader than the similar deflected portion of the opposite valve; mesial fold not differentiated from the general curvature of the valve except in the sinuosity of the anterior line of junction of the two valves; the beak pointed and incurved beneath that of the opposite valve; plications similar in form and number to those of the opposite valve.

Surface of both valves marked by fine, regular, concentric lines of growth which follow the direction of the serrate margin, upon the older portion of the shell they are commonly obliterated, even upon the best preserved specimens, but towards the margin they are clearly defined unless the surface is exfoliated, a few stronger lines of growth are usually present at irregular intervals, or they may be entirely absent; besides the concentric lines the surface is marked by exceedingly fine radiating striæ which are best observed only upon the postero-lateral deflected portions of the valves, and are entirely obliterated upon exfoliated shells.

Remarks.—The internal characters of representative examples of this species have not been carefully examined because of the lack of material, but enough has been seen to show that these structures are essentially identical with those of *T. subcuneata.* Indeed the whole aspect of a good example of the species is that of a rather large specimen of *T. subcuneata,* and it is perhaps ill-advised to consider these two species as distinct. If *T. arctirostrata* is a good species it must rest upon its larger size, deeper brachial valve, and especially upon the fine radiating costæ.

Horizon.—Salem limestone.

Tetracamera missouriensis n. sp.

Plate XXVIII, Figs. 35-39

Description.—Shell of medium size or usually somewhat smaller, triangularly subovate in outline, the greatest width anterior to the middle, usually longer than wide, the long postero-lateral margins nearly straight

and meeting at the beak in an acute angle, the anterior and antero-lateral margins subsemicircular, the line of junction between the two valves deeply and sharply serrate, especially along the anterior and antero-lateral margins. The dimensions of an internal cast of a pedicle valve are: length 22.9 mm., greatest width 20 mm., convexity 4.8 mm. The dimensions of an internal cast of a brachial valve are: length 22.7 mm., width 19.4 mm., convexity 8 mm.

Pedicle valve nearly flat throughout the greater portion of its surface, gently convex in the umbonal region, abruptly deflected along its postero-lateral margins and only a little less abruptly deflected along the anterior and antero-lateral margins; mesial sinus essentially obsolete or represented only by a slight sinuosity of the margin upon the anterior deflected portion of the valve; beak acutely pointed, only moderately incurved; plications twenty to twenty-six in number, rounded or subangular, usually simple and extending from the beak to the margin, but occasionally with one or two intercalated plications anterior to the beak, the plications becoming successively smaller towards the postero lateral margins, those upon the deflected postero-lateral surfaces of the valve curving rather strongly towards the margin. Internally the dental plates are well developed and are joined near the inner surface of the valve to form a spondylium which is supported by a well defined median septum which reaches anteriorly about one-third the length of the valve, from the outer surface of each dental lamellæ a lateral buttress plate passes to the inner surface of the postero-lateral deflected portion of the valve, the buttress plates extending anteriorly from the beak for about one-third the length of the median septum.

Brachial valve similar in contour to the pedicle, with the postero-lateral surfaces abruptly deflected to meet the similarly deflected portions of the opposite valve, and the anterior and antero-lateral margins also deflected in a manner similar to that of the opposite valve, the non-deflected surface of the valve somewhat more convex than that of the pedicle valve, and the depth of the valve a little greater; mesial fold obsolete except for the slight sinuosity in the anterior margin; the beak acutely angular and incurved beneath that of the opposite valve; plications similar in form and number to those of the pedicle valve. Internally the median septum extends anteriorly from the beak for from one-third to nearly one-half the length of the valve, the lateral lamellæ which support the inner margins of the divided hinge-plate join the inner surface of the valve at the base of the median septum so that the three lamellæ make but a single median slit in the internal casts of the valve.

The minute surface markings not preserved upon the internal casts, to which observations were limited.

Remarks.—The specimens here described occur commonly in the cherts of Callaway County, Missouri, the locality and horizon of the type of the species described by Swallow as *Rhynchonella ringens*, and they conform in general outline with the shell suggested by the original definition of that species. However, no examples have been observed by the writer to attain more than about one-half the size of Swallow's type and none of the specimens exhibit a distinct mesial sinus, which, in the original definition of the species, is said to be broad and shallow; furthermore, the plications are more numerous. If the shell here defined should ever attain so large a size as is indicated by Swallow, it is not improbable that a shallow mesial sinus might be developed, but the number of plications ought to be somewhat greater in the larger example rather than smaller. However, if this shell does not belong to Swallow's species, and it is believed that it does not, it must be an undescribed form.

The species most closely resembles *T. arctirostrata*, but it is a larger and more elongate shell, and in the specimens observed, lacks a mesial depression in the anterior portion of the pedicle valve. The species may further be differentiated by reason of the occasional intercalation of plications, in some specimens, which has not been observed in *T. arctirostrata*.

Locality.—Callaway County, Missouri (residual chert).

Tetracamera subtrigona (Meek and Worthen)

Plate XXIX, Figs. 1-13

1860. *Rhynchonella subtrigona* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 451.
1860. *Rhynchonella Parvini* McChesney, Desc. New Foss., pt. 2, p. 83.
1865. *Rhynchonella Parvini* McChesney, Plates Ill. New Spec. Foss., pl. 6, figs. 2a-b.
1866. *Camarophoria subtrigona* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 251, pl. 18, figs. 7a-e.
1868. *Camarophoria subtrigona* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 31, pl. 6, figs. 2a-b.
1894. *Camarophoria subtrigona* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 45, figs. 1-2.
1894. *Rhynchonella subtrigona* Keyes, Mo. Geol. Surv., vol. 5, p. 102.
1895. *Camarophoria subtrigona* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 62, figs. 38-43.
1895. *Camarophoria ringens* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 84, fig. 45.
1910. *Camarophoria ringens* Greger, Am. Jour. Sci. (4), vol. 29, p. 71, figs. 7-8.
1910. *Tetracamera subtrigona* Weller, Bull. Geol. Soc. Am., vol. 21, p. 504, fig. 5.

Description.—Shell of medium size or larger, broadly subtriangular or subpentagonal in outline, wider than long, truncated in front, with broad,

simple plications. The dimensions of a nearly complete but somewhat distorted individual are: length 32.5 mm., width 37 mm., thickness 27 mm.

Pedicle valve flattened on the umbo and in front of the umbo, gently convex from the beak to the front in the median portion, abruptly deflected near the margin, the front of the shell being nearly at right angle to the flattened umbonal region, towards the antero-lateral margins the surface is at first elevated by a gentle concavity and is then abruptly deflected towards the opposite valve forming a sort of angular crest along each antero-lateral margin, the postero-lateral margins are nearly straight and meet at the beak at an obtuse angle of about 110 degrees, along these margins the surface is abruptly bent towards the opposite valve, and is usually somewhat inflected forming with a similar area on the opposite valve, an obscurely plicated, flattened or concave area on each side of the beak; mesial sinus broad, shallow, ill-defined, becoming somewhat deeper anteriorly; the beak small, pointed and moderately incurved; the plications are strong, simple, rounded or a little subangular, and are separated by more angular furrows, from 14 to 20 are present on the valve, several

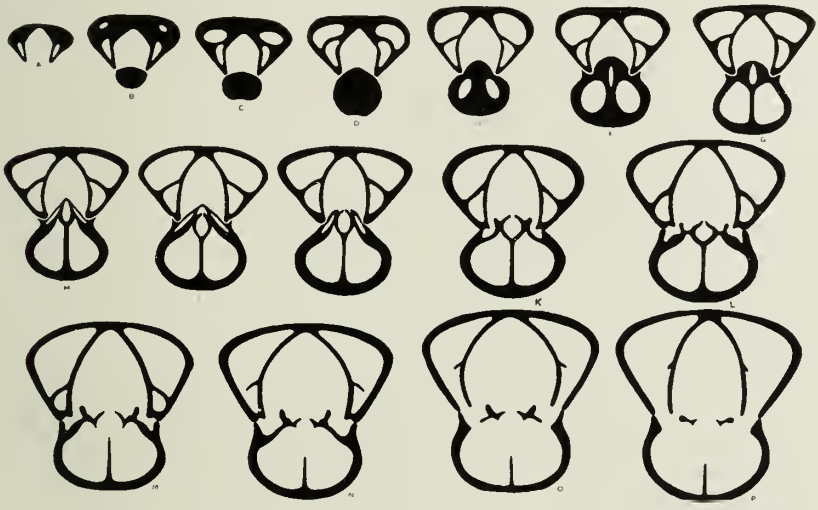

FIG. 17.—A series of sixteen cross-sections of the rostral portion of the shell of *Tetracamera subtrigona* (× 1¼), showing the characters of the internal lamellæ.

next the postero-lateral margins often being faint or nearly obsolete, about six or seven occupy the mesial sinus, the margin of the valve is deeply and acutely serrate, the projections being opposite the furrows between the plications, the deepest and strongest serrations are in the front of the shell, on each side they decrease in strength with the weakening of the plications. Internally a strong median septum extends from the beak nearly to the line of deflection of the valve near its anterior

margin and is often more or less abruptly thickened near its anterior extremity, this septum supports a spondylium whose spreading sides meet at an angle in the bottom.

Brachial valve much deeper than the pedicle, the greatest depth near the front margin; from this point the surface slopes with a gentle convex curvature to the beak, and is abruptly deflected to the anterior and antero-lateral margins, along the postero-lateral margins the surface is abruptly bent towards the opposite valve and is usually somewhat inflected and forms more than one-half of the smooth, oval, concave areas on each side of the beak; mesial fold obsolete posteriorly, broad and ill-defined anteriorly; the beak is strongly incurved beneath that of the opposite valve and partly fills the delthyrium of that valve, the plications are similar to those of the opposite valve and are alternate with them, as are the serrations on the margin, the plications towards the postero-lateral margins are strongly arched. Internally the valve bears a strong median septum which extends from the beak more than half way to the line of deflection of the valve towards its anterior margin, in its anterior half this median septum bisects a subovate or subelliptical muscular impression, at the beak of the valve it supports a subquadrangular, spoon-shaped hinge-plate whose ventral surface is depressed medially through about one-third its width, the lateral margins of this depressed region diverge from a point at the beak and are overhanging so as to give to the depressed region the appearance of a flattened, conical tube cleft along one side.

In addition to the plications each valve is marked only by concentric lines of growth which are obscure or obsolete over the greater portion of the shell, ordinarily being clearly recognizable only upon the deflected portion of the valves near the anterior margin.

Remarks.—This species has been most commonly recognized in the residual cherts of the Keokuk limestone, where it occurs in the condition of internal casts showing clearly the median septum in each valve and the muscular impressions of the brachial valve. Where it has been found *in situ* it is known only in the Keokuk limestone. Hall and Clarke[1] have illustrated an internal cast under the name *Camarophoria ringens* Swallow, which is clearly an example of Meek and Worthen's *Rhynchonella subtrigona,* and more recently a specimen of the same species has been figured by Greger[2] as typical of Swallow's species. Swallow's type has been destroyed but the specimen illustrated by Greger is said to bear a label written by Swallow himself and is therefore considered by that writer to be authentic, a conclusion which, if true, would necessitate Swallow's name taking precedence over that of Meek and Worthen. A careful examina-

1 Pal. N. Y., vol. 8, pt. 2, pl. 84, fig. 45. (1895.)
2 Am. Jour. Sci. (4), vol. 29, p. 71, figs. 7-8. (1910.)

tion of a score or more of good examples of Meek and Worthen's species, in comparison with Swallow's original definition of *R. ringens*, brings out the fact that they are always very different in outline from the shell indicated by Swallow. *R. subtrigona* is always notably broader than long, while *R. ringens* is distinctly defined as being longer than broad. The species is a close ally of the rare *R. isorhyncha* M'Coy, from the Monntain Limestone fauna of Ireland, but the American species is much broader than the Irish form with more conspicuously deflected anterior and antero-lateral margins. The crest-like elevation of the antero-lateral margins of the pedicle valve of *C. subtrigona* is also lacking in *C. isorhyncha*.

The internal characters of this shell differ somewhat notably from those of the genotype of *Tetracamera*. The charaeteristic buttress plates are present in the pedicle valve, but the arrangement of the lamellæ in the rostral portion of the brachial valve is quite different. These differences may be best comprehended through a comparison of the sections which are given of the two speeies. It is possible that this species should properly be recognized as a member of a distinct genus, but for the present it seems best to eonsider it as congeneric with *T. subcuncata*.

Horizon.—Keokuk limestone.

Genus *SHUMARDELLA* Weller

Description.—Shell rhynchonelliform, usually below medium size, subovate to subpentagonal in outline, often subglobular in form, the mesial fold and sinus well developed anteriorly, the anterior margin of the sinus much produced; the surface marked by broad, low, rounded or subangular plications which arc more strongly defined on the fold and sinus, and which may be nearly obsolete. Internally the dental lamellæ of the pedicle valve are well developed. In the brachial valve a strong median septum is present and is divided internally to form a narrow and deep crural cavity which is closed on its cardinal side, this closure being continuous to beyond the point where the median septum is joined to the hinge-plate, the lateral walls of the crural cavity being snspended in the cavity of the valve for a short distance beyond the point where they are connected with the median septnm. The crura are formed by the anterior extension of the walls of the crural cavity where they are joined to the hinge-plate.

Remarks.—This genus is characterized by the obsolescent plications of the shell and by the crural cavity which is short in an antero-posterior direction and entirely closed on its cardinal side.

Shumardella missouriensis (Shumard)

Plate XXV, Figs 43-52

1855. *Rhynchonella Missouriensis* Shumard, Geol. Rep. Mo., p. 204, pl. C, figs. 5a-c.
1894. *Rhynchonella missouriensis* Keyes, Mo. Geol. Surv., vol. 5, p. 100.
1910. *Shumardella missouriensis* Weller, Bull, Geol. Soc. Am., vol. 21, p. 512, fig. 14.

Description.—Shell below medium size, triangularly subovate in outline, usually wider than long, the greatest width anterior to the mid-length, the postero-lateral margins nearly straight, meeting at the beak in an angle of about 100 degrees, the antero-lateral margins rounded, the anterior margin nearly straight or slightly emarginate. The dimensions of two nearly perfect specimens are: length 20 mm. and 18 mm., width 22.4 mm. and 17.9 mm., thickness 16.5 mm. and 15 mm., width of sinus in front 16 mm. and 14.8 mm.

Pedicle valve very shallow, the umbo narrowly convex, usually with a small concave region on either side, beyond which a narrow margin, becoming abruptly wider towards the beak, is sharply inflected, towards the antero-lateral margins the surface is nearly flat or slightly convex, and from the beak to the front along the median line it is strongly but not regularly arched; the mesial sinus originates posterior to the middle of the valve, it is broad and of moderate depth with the surface rather ab-

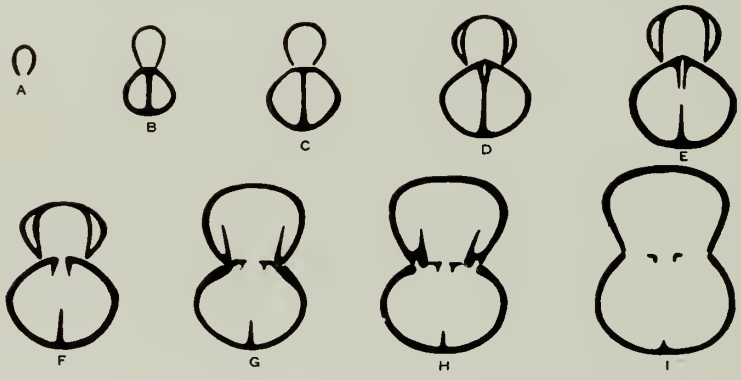

Fig. 18.—A series of nine cross-sections of the rostral portion of the shell of *Shumardella missouriensis* (× 2½), showing the dental lamellæ of the pedicle valve, the hinge-plate, median septum, crural cavity, and crura of the brachial valve.

ruptly curved towards the opposite valve anteriorly and produced into a broad, lingual extension at nearly a right angle to the plane of the valve, it is coarsely serrate on the front margin; beak small, pointed, moderately incurved; the delthyrium nearly filled by the beak of the opposite valve,

the deltidial plates not observed; plications few in number, broad, low, rounded, two, or more rarely three, originating on or just in front of the umbonal region and occupy the bottom of the sinus, on each lateral slope of the valve two plications are usually present which are fainter than those of the sinus and originate closer to the margin. Internally the teeth are supported by a pair of dental plates which quickly become obsolete in front of the articulation of the hinge.

Brachial valve gibbous, the greatest depth near the front margin in adult examples, the surface usually slopes along the median line from the point of greatest convexity to the beak with a nearly regular curvature, becoming a little more convex near the beak, anteriorly there is often a short but somewhat abrupt slope to the margin, towards the lateral margins the surface curves at first gently and then more abruptly from the median line, and towards the beak on either side there is a distinct and sometimes rather deep lateral concave region; mesial fold scarcely or not at all differentiated in the posterior half of the valve, usually becoming more prominent anteriorly; beak incurved beneath that of the opposite valve; plications similar in form and number to those of the opposite valve, the three or rarely four of the mesial fold alternate with those of the sinus and are the strongest ones on the valves, those of the lateral slopes often nearly or quite obsolete. Internally there is no cardinal process, a thin and rather short median septum is present supporting the initial portion of the hinge-plate, at the apex of the beak this septum is not divided but anteriorly it is split into two parts, one of which supports each side of the hinge-plate, but the base of the hinge-plate is solid and roofs over the cavity between the two divisions of the septa, so that they do not form an open crural cavity such as is present in the genus *Camarotœchia*, anteriorly the hinge-plate is divided and at the point of articulation of the hinge the two divisions are separate and the median septum is so much reduced that it no longer supports them. The crura extend from the anterior extremities of the divided hinge-plate into the cavity of the shell.

The surface of both valves is marked by fine, regular, concentric striæ, and usually by several stronger, irregularly developed, concentric lines of growth towards the front.

Remarks.—This species has been frequently misinterpreted. Every published illustration to which the name has been applied, save only the original one by Shumard, is incorrectly identified, and even this author has represented two different species. The name *missouriensis* is here retained for the larger form illustrated by Shumard, and the one with which his description more fully agrees. The species is restricted to the Chouteau limestone fauna and is most commonly represented in the typical Chouteau limestone in central Missouri.

The later authors who have referred to the species have placed it in the genus *Pugnax*, but the distinct median septum of the brachial valve, which is divided above for the support of the hinge-plate is entirely different from those characters in *Pugnax*. It differs from *Camarotœchia* in the arching over of the cavity between the divisions of the median septum by the undivided basal portion of the hinge-plate, and by the consequent absence of the open crural cavity at the base of the hinge-plate. These internal characters, as well as the external aspect of the shell, distinguish the species from any of the recognized generic divisions of rhynchonelloid shells and it is in consequence made the type of a new genus.

Horizon.—Chouteau limestone.

Shumardella obsolens (Hall)

Plate XXVI, Figs. 1-9

1855. *Rhynchonella obscura-plicata* Shumard, I and II, Rep. Geol. Surv. Mo., p. 218. (Name only.)
1855. *Rhynchonella Missouriensis* Shumard, I and II Rep. Geol. Surv. Mo., p. 204, pl. C, fig. 5a (not figs. 5b-e).
1860. *Rhynchonella* (*Eatonia*) *obsolens* Hall, 13th Rep. N. Y. State Cab. Nat. Hist., p. 111.
1866. *Rhynchonella missouriensis* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 153, pl. 14, figs. 4a-b.
1910. *Shumardella obsolescens* Weller, Bull. Geol. Soc. Am., vol. 21, p. 513, fig. 15.

Description.—Shell below medium size, nearly smooth, subglobular in form, wider than long, the greatest width near the mid-length, posterior lateral margins meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin emarginate. The dimensions of two perfect specimens are: length 15.9 mm. and 14.4 mm., width 16.7 mm. and 16.4 mm., thickness 13.7 mm. and 12.8 mm., width of sinus in front 11 mm. and 9.5 mm.

Pedicle valve shallow, convex on the umbo, the surface gently convex from the umbo to the antero-lateral margins, curving strongly to the postero-lateral margins, the curvature becoming more abrupt towards the beak, from the beak to the front margin along the median line the curvature of the surface is a subsemicircle; mesial sinus obsolete in the umbonal region, originating as a broad, shallow, rounded depression posterior to the middle of the shell and becoming rapidly deeper anteriorly, in front it is produced in a broad, elongate, terminally rounded lingual extension which retains its concavity to the end giving to the shell its emarginate outline in front; beak small, incurved, nearly in contact with the umbo of the opposite valve; the delthyrium nearly filled by the beak of the opposite valve, the deltidial plates obscure and not observed in any of the specimens studied, the foramen small; plications nearly obso-

lete, from two to five, more usually two or three, originate on or in front of the umbonal region and pass to the anterior margin along the bottom of the sinus, these plications are low and rounded, somewhat variable in strength but always comparatively faint, upon the lateral slopes of

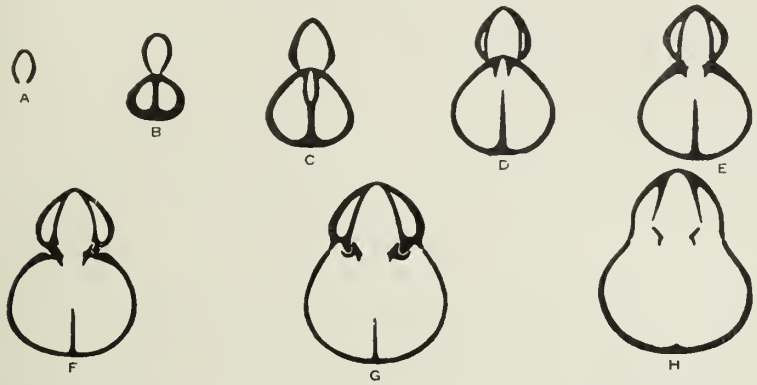

FIG. 19.—A series of eight cross-sections of the rostral portion of the shell of *Shumardella obsolens* (× 2½), showing the internal characters.

the valve the plications are obsolete. Internally the hinge-teeth are supported by short dental plates which scarcely extend beyond the articulation of the hinge.

Brachial valve gibbous, the umbonal region protuberant, sometimes extending nearly as far as the beak of the opposite valve, the greatest convexity near the anterior margin, the surface strongly convex from beak to front along the median line, and much more strongly convex transversely, towards the beak the surface on each side is a little inflected to form, with a similar inflected portion of the opposite valve, a small, more or less conspicuous concave lateral region; mesial fold obscure or obsolete in the posterior half of the valve, becoming a little more conspicuous anteriorly, but rarely or never strongly differentiated from the general surface of the valve; the beak incurved beneath that of the opposite valve; plications obscure as in the opposite valve, the stronger ones are confined to the mesial fold where they alternate with those of the sinus of the opposite valve, upon each lateral slope two or three exceedingly faint plications may occasionally be detected, but they are more apt to be entirely obsolete. Internally there is no cardinal process; the hinge-plate is divided but not to the base at the apex of the valve, it is supported posteriorly by a median septum which is simple at first but is divided above anteriorly, each division supporting one side of the hinge-plate, the support of the hinge-plate by the divided septum does not continue beyond the median incision of the hinge-plate itself so that no open crural cavity occurs, but rather an enclosed cavity roofed

over by the joined portion of the hinge-plate and open only in an anterior direction, the support of the hinge-plate by the septum is discontinued before the line of articulation is reached and from this point forward each lateral division of the hinge-plate is unsupported, anteriorly each division is produced into the cavity of the valve as one of the crura.

Surface of both valves marked by fine, rather regular concentric striae and by occasional strong lines of growth.

Remarks.—Shumard illustrated two different individuals with his original description of *Rhynchonella missouriensis*, fig. 5a being a smaller and much smoother shell than figures 5b-c. The original description was evidently made from the larger and more strongly plicated shell, and that is here taken as the typical form of the species. Both of the illustrated forms are commonly represented in collections of the Chouteau limestone fauna from central Missouri, and while an imperfect gradation from one form to the other can be traced, the two forms are easily distinct enough to be considered as different species. In his lists of species Shumard records *R. obscura-plicata*, a name by which he undoubtedly designated the shell here described, although he never defined it, and the name by which Missouri collectors have known it since that time. In 1860 Hall described *Rhynchonella obsolens*, without illustrations, from the goniatite-bearing Rockford limestone of Indiana, and his description agrees fairly well with examples of this smooth form from the Chouteau limestone of Missouri. In 1866 Meek and Worthen described and illustrated as *R. missouriensis* a shell from the same Rockford limestone which agrees satisfactorily with the smooth form of that shell as illustrated by Shumard, and it is more than probable that the observers had representatives of the same shell as that described by Hall. Under these circumstances, therefore, if we restrict the use of the name *missouriensis* to the larger shell of Shumard, either Hall's name or Shumard's *obscura-plicata* may be available for the form here described, and the latter of these must be ruled out because it was never properly defined.

In their generic characters, as shown by serial sectioning of the shells, *R. missouriensis* and *R. obsolens* are identical, but they cannot be included in any of the recognized generic divisions of rhychonelloid shells and have been made to constitute the new genus *Shumardella*. *S. obsolens* may be distinguished from *S. missouriensis* by its smaller size, its more globose and less angular form, its much smoother and less strongly plicated shell, and by the more distinctly emarginate anterior outline.

The species has some external resemblance to members of the genus *Liorhynchus* and has sometimes been incorrectly identified as *L. boonensis*, a rare species which was originally described from the Burlington limestone.

Horizon.—Chouteau limestone.

Genus *RHYNCHOPORA King*

Description.—Shell rhynchelliform, below medium size, usually pentangularly ovate in outline, the mesial fold and sinus well developed in the anterior half of the shell, both valves marked by simple, subangular or rounded plications which are sometimes longitudinally grooved towards the front. Internally the dental lamellæ are well developed in the pedicle valve. Brachial valve with a strong median septum in the rostral portion, which is divided internally to form the walls of a crural cavity; this is covered over on its cardinal side by the undivided hinge-plate, the hinge-plate continuing anteriorly beyond the anterior termination of the crural cavity; the crura formed by the anterior extension of that part of the hinge-plate opposite the lateral walls of the crural cavity. Shell structure punctate.

Remarks.—No opportunity has been afforded the writer to make a study of the internal characters of *R. geinitziana*, the genotype of *Rhynchopora*, so there is a possibility of a wrong interpretation of the genus in this place. Up to the present time the one essential generic character which has been recognized is the punctate structure of the shell, but in *R. pustulosa*, the only American species recognized by Hall and Clarke[1] and by Schuchert,[2] the undivided hinge-plate and the complete closure of the crural cavity except anteriorly, are good differential characters. All other species included in the genus in this place, except one, agree in the character of the hinge-plate and crural cavity with *R. pustulosa*. The punctate structure of the shell is conspicuously developed in only one of the species here recorded, *R. beecheri*, which has been observed only in the condition of internal casts and impressions of the exterior, no serial sections of the rostral portion of the shell have been made, but the hinge-plate and crural cavity are apparently as in *R. pustulosa*. The Pennsylvanian species *R. illinoisensis* is another one which is conspicuously punctate, but its internal characters have not been worked out. In *R. pustulosa* the punctate structure of the shell is so obscure as to almost lead one to believe, at times, that it is absent, and in one or two of the species here included in the genus no punctate structure has yet been observed. Another character which differentiates most of these shells from other Mississippian rhynchonelloids is the longitudinal grooving of the flattened plications towards the front, especially those of the fold and sinus, this condition being altogether similar to that in *Wilsonia* and some other older rhynchonelloids. This character is not shown upon any of the illustrations of *R. geinitziana* which have been available for examination, and it is not present in *R. hamburgensis* described in this work. On the whole, *R. hamburgensis* seems to correspond most closely

[1] Pal. N. Y., vol. 8, pt. 2, p. 210. (1894.)
[2] Synop. Am. Foss. Brach., p. 366. (1897.)

in the sum of all its characters, with the genotype, although the punctate structure is much more obscure. It is possible that future investigations of this group of shells will make it necessary to recognize one or more additional genera.

Rhynchopora hamburgensis Weller

Plate XXIX, Figs. 19-30

1910. *Rhynchopora hamburgensis* Weller, Bull. Geol. Soc. Am., vol. 21, p. 515, fig. 17.

Description.—Shell small with valves very unequally convex in mature specimens, triangularly subovate in outline, the postero-lateral margins meeting at the beak in an obtuse angle, the antero-lateral margins rounded, the anterior margin nearly straight or a little concave. The dimensions of two examples are: length 10.2 mm. and 9 mm., width 11.1 mm. and 9.8 mm., thickness 8 mm. and 5.5 mm., width of sinus in front 8 mm. and 6.3 mm.

Pedicle valve shallow, convex in the umbonal region, the surface curving rather abruptly to the postero-lateral margins, gently convex from the umbo to the antero-lateral margins, and strongly arched in adult shells along the median line from the beak to the front margin; mesial sinus originating near the middle of the valve as a broad, shallow, concave depression which becomes deeper anteriorly, not abruptly depressed below the lateral slopes of the valve, produced anteriorly in adult shells in a broad lingual extension rounded in front, whose surface lies in nearly a right angle to the plane of the valve; beak rather broad, not strongly incurved, pierced by a subcircular foramen, rather conspicuously extended posteriorly beyond the opposite valve; delthyrium broadly triangular, partially filled by the beak of the opposite valve, communicating at

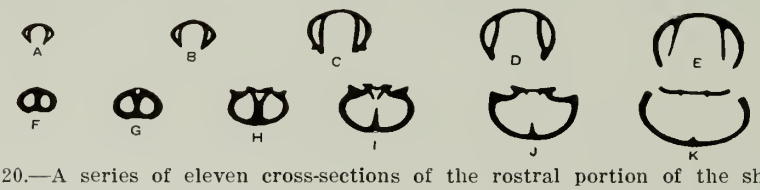

Fig. 20.—A series of eleven cross-sections of the rostral portion of the shell of *Rhynchopora hamburgensis* (× 2½); A to E, the pedicle valve, showing the dental lamellæ; F to K, the brachial valve, showing the undivided hinge-plate, the median septum, and covered crural cavity.

the apex with the foramen which encroaches upon the beak, deltidial plates not observed; plications simple, rounded or subangular, originating at the beak, from three to six, more usually four or five, occupy the sinus, and about five each lateral slope. Internally the hinge teeth are supported by a pair of short dental plates which quickly become obsolete in front of the articulation of the hinge.

Brachial valve more convex than the pedicle, becoming gibbous in mature shells, the umbonal region flattened longitudinally or sometimes with a slight mesial depression, the greatest convexity at or near the front margin, the surface sloping from the point of greatest convexity to the beak with an increasing curvature and with a more or less abrupt curvature to the front, laterally from the median line the surface is at first gently convex but soon curves abruptly to the margins; the mesial fold obsolete in the posterior half of the valve and only moderately or not at all differentiated anteriorly; the beak broad, incurved beneath that of the opposite valve; the plications similar in form and number to those of the opposite valve and alternate with them. Internally the cardinal process is lacking and the hinge-plate is undivided, although the median portion is differentiated from the lateral portions, it being thinner and usually either a little concave or a little convex; a median septum is present at the beak which is soon divided, one branch supporting each of the lateral divisions of the hinge-plate, but because of the continuous hinge-plate the pit between the divisions of the septum is not an open crural cavity as in *Camarotœchia*, but is a covered excavation open only towards the front; a little posterior to the articulation of the hinge, the median septum and its divisions which support the hinge-plate become discontinuous, the septum continuing as a gradually disappearing ridge for about one-fourth the length of the valve from the posterior extremity.

Surface of both valves, apart from the plications, nearly or quite smooth, except for a few obscure lines of growth near the anterior margin of adult shells. The shell structure is minutely punctate and in at least one specimen the perforations are arranged in longitudinal rows, a single row upon each slope of each plication.

Remarks.—This species occurs abundantly in the Hamburg oolite of Kinderhook age, at Hamburg, Calhoun County, Illinois. Externally, it somewhat resembles, in size and general form, the *Camarotœchia chouteauensis* from the Chouteau limestone, but its plications are less angular, its fold and sinus are less abruptly differentiated from the lateral slopes, and its beak is less incurved and more produced posteriorly. Internally the two forms are fundamentally different, *R. hamburgensis* having the continuous hinge-plate of the genus *Rhynchopora*, while in *C. chouteauensis* the hinge-plate is medially divided and the characters are those of *Camarotœchia*. The two species are also differentiated by the punctate shell structure of *R. hamburgensis*.

The internal characters of the species have been determined by the study of serial sections made by grinding detached valves. These detached valves have, of course, been subjected to accident during deposition, and in no case have the crura been detected, although they were undoubtedly present as anterior prolongations from the lateral divisions of the hinge-plate. In some of the specimens examined the median por-

tion of the hinge-plate has also been destroyed, this part being distinctly thinner and more delicate than the lateral portions and therefore much more easily destroyed. The continuous hinge-plate has been observed in a sufficient number of individuals, however, to make it certain that that was the normal condition of the species. The punctate structure of the shell is an obscure feature and in many individuals it cannot be detected at all on account of the condition of preservation of the shell. It is occasionally shown, however, and in the specimen in which it is best exhibited the perforations are not distributed uniformly over the entire shell but occur in longitudinal lines, one upon each lateral slope of each plication. This is probably the normal condition towards the beak but it is possible that they become more scattered towards the anterior margin of the shell.

Horizon.—Hamburg oolite of the Kinderhook.

Rhynchopora pustulosa (White)

Plate XXIX, Figs. 14-18; Plate XXIV, Fig. 82

1860. *Rhynchonella pustulosa*, White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 236.
1894. *Rhynchopora pustulosa* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 44, figs. 26-29.
1895. *Rhynchopora pustulosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 58, figs. 1-4.
1901. *Rhynchopora pustulosa* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 157, pl. 13, figs. 4-6.
1904. *Rhynchopora pustulosa* Greger, Am. Geol., vol. 33, p. 298-299, figs. 10-12.
1910. *Rhynchopora pustulosa* Weller, Bull. Geol. Soc. Am., vol. 21, p 514, fig. 16.

Description.—Shell below medium size, subpyramidal in form, wider than long, the greatest width near or in front of the mid-length of the shell, the postero-lateral margins a little concave, meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin nearly straight or gently convex. The dimensions of a nearly perfect specimen are: length 12.3 mm., width 12.6 mm., thickness 10.3 mm., width of the sinus in front 8.5 mm.

Pedicle valve convex in the umbonal region with a sigmoidally curved slope to the cardinal margin, to the antero-lateral margin the surface is gently convex and from the beak to the front margin along the median line it is strongly arched in nearly a semicircle; the mesial sinus is obsolete in the posterior half of the valve, it originates near or in front of the middle of the valve as a broad, shallow, flattened depression and continues as such to the anterior margin, anteriorly it is produced in a broad, lingual extension rounded in front with a serrate margin, whose surface in front lies in nearly a right angle to the plane of the valve; the beak large, moderately incurved, perforated by a large, subcircular foramen;

the delthyrium broadly triangular, nearly filled by the beak of the opposite valve, communicating at its apex with the foramen which encroaches upon the beak of the valve; plications rather coarse, rounded or subangular, simple, originating at the beak, three or rarely four

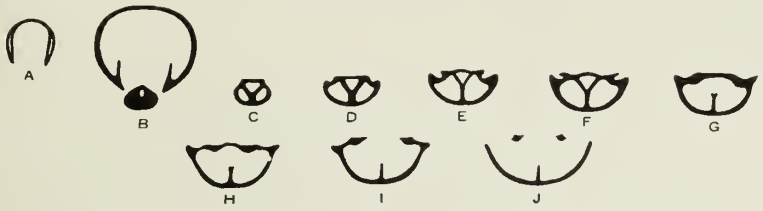

FIG. 21.—A series of ten cross-sections of the rostral portion of the shell of *Rhynchopora pustulosa* (× 2½), only the first two (A and B) with the pedicle valve; sections C to J show the undivided hinge-plate, the median septum, and covered crural cavity.

occupying the mesial sinus, and from four to six each lateral slope, those towards the postero-lateral margins becoming faint or almost obsolete, the plications in the sinus marked by a slight median groove for some distance back from the anterior margin. Internally the hinge-teeth are supported by a pair of dental lamellæ whose length is equal to from one-fifth to one-fourth the length of the valve.

Brachial valve much more convex than the pedicle, becoming gibbous in front, the surface sloping with a long, regular, or an increasing curvature, from the highest point to the beak, and with a short, usually more convex curvature to the anterior margin, the lateral slopes strongly convex from beak to front, the anterior slope more abrupt, and curving abruptly to the lateral margins; mesial fold obsolete in the posterior half of the valve and only slightly differentiated in front; the beak incurved beneath that of the opposite valve; the plications similar in form and number to those of the opposite valve. Internally the cardinal process is absent and the hinge-plate is undivided; a conspicuous median septum is present which extends one-third the length of the valve or more from the beak, posteriorly the median septum is divided, the two branches supporting the hinge-plate and forming with it a crural cavity, triangular in cross section, which is open only towards the front, the divided septum continues to the position of the articulation of the hinge, beyond which the septum is free, the hinge-plate is continued anteriorly in the crura.

Aside from the plications the surface of both valves is marked by concentric lines of growth which are of irregular strength and are irregularly arranged, usually being inconspicuous. The shell structure is finely and closely punctate.

Remarks.—The punctate structure of the shell is commonly rather obscure in examples of this species which have come under observation. The internal structures of the rostral portion of the brachial valve, however, especially the undivided hinge-plate, always seem to be present in specimens which are clearly punctate, and it is believed that they are all congeneric.

Horizon.—Kinderhook.

Rhynchopora beecheri Greger

Plate XXIX, Figs. 31-38

1904. *Rhynchopora beecheri* Greger, Am. Geol., vol. 33, p. 297, figs. 4-9.
1910. *Rhynchopora beecheri* Weller, Bull. Geol. Soc. Am., vol. 21, p. 515.

Description.—Shell below medium size, triangularly subovate in outline, subpyramidal in form, broader than long in adult individuals, the greatest breadth near the mid-length of the shell. The postero-lateral margins nearly straight or gently convex, meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin usually nearly straight. The dimensions of a nearly complete internal cast are: length 10.5 mm., width 12.8 mm., thickness 10 mm., width of sinus in front 8 mm.

Pedicle valve depressed convex in the umbonal region with the surface flattened or gently convex towards the antero-lateral margins, the serrate lateral margins abruptly deflected towards the opposite valve; along the median line the surface is gently convex to near the anterior border of the shell and is there abruptly curved towards the opposite valve; the mesial sinus originates near or a little back of the middle of the valve as a rather broad, shallow depression, usually a little convex transversely across the bottom, becoming gradually deeper anteriorly and curving rather abruptly towards the opposite valve as it approaches the anterior margin of the shell, produced in a broad lingual extension with a nearly straight and deeply serrate distal margin whose surface in front lies in nearly a right angle to the plane of the valve; the beak rather broad and but little incurved, perforated by a subcircular foramen; the delthyrium broadly triangular and nearly filled by the beak of the opposite valve; plications rounded or subangular, simple, originating in the umbonal region on internal casts but probably continuing to the beak upon the surface of the shell, from four to six occupy the sinus and from five to eight each lateral slope. Internally the hinge-teeth are supported by a pair of dental lamellæ which extend from one-third to one-half the length of the valve.

Brachial valve much more convex than the pedicle, becoming gibbous anteriorly in adult specimens, the surface slopes from the point of greatest convexity posteriorly in a long convex curve which increases towards the beak, and in a short, more abrupt curve to the anterior margin, trans-

versely from the median line the surface is at first gently convex and then curves abruptly to the lateral margins, the curvature being a little broken towards the front by the differentiation of the median fold, the lateral slopes are strongly arched from beak to front with a more abrupt curvature to the front; the mesial fold is obsolete in the posterior half of the valve and is but moderately elevated above the lateral slopes in front; the beak incurved beneath that of the opposite valve. Internally the cardinal process is absent and the hinge-plate is undivided; a strong median septum is present which is divided posteriorly, each branch supporting one side of the hinge-plate, between the divisions of the septum is a crural cavity triangular in cross section, covered on one side by the hinge-plate and open only towards the front, anteriorly the septum is free and reaches from one-third to one-half the length of the valve.

The surface markings of the shell, aside from the plications, are not clear on the internal casts, but fragments of external moulds indicate that it was nearly or quite smooth. The shell structure is finely and closely punctate, the punctæ being much more abundant upon, and seem sometimes to be confined to, the tops of the plications. The punctæ render the surface of the internal casts finely papillose, and when the internal cast and mould of the exterior are examined together the two surfaces are joined by innumerable, minute, transverse pillars which are the siliceous casts of the perforations through the shell.

Remarks.—This species resembles *R. pustulosa* but has somewhat finer and more numerous plications, and the entire aspect of the shell is more angular in form. The internal characters of the species are identical in all fundamental respects, but the dental lamellæ of the pedicle valve are somewhat longer, and the divided portion of the septum of the brachial valve seems to continue further towards the front in *R. beecheri*. The species is most commonly preserved as internal casts and external moulds in the cherts of the Keokuk limestone, and it has not been observed in any other condition by the writer. The punctate character of the shell and the internal rostral characters are easily recognized in the chert specimens.

Horizon.—Residual Keokuk chert.

Rhynchopora persinuata (Winchell)

Plate XXX, Figs. 1-6

1865. *Rhynchonella persinuata* Winchell, Proc. Acad. Nat. Sci. Phil., p. 121.

1881 *Camarophoria occidentalis* Miller, Jour. Cinn. Soc. Nat. Hist., vol. 4, p. 313, pl. 7, figs. 7-7b.

1901. *Camarotachia persinuata* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 197, pl. 19, fig. 5.

1909. *Camarotachia persinuata* Weller, Bull. Geol. Soc. Am., vol. 20, p. 302, pl. 12, figs. 24-25.
1910. *Rhynchopora persinuata* Weller, Bull. Geol. Soc. Am., vol. 21, p. 515.

Description.—Shell below medium size, subpyramidaal in form, wider than long, the postero-lateral margins meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin straight. The dimensions of an incomplete internal cast are: length 17 mm., width 20 mm., thickness 13.7 mm., width of sinus in front 11.5 mm.

Pedicle valve depressed convex in the posterior half, with the surface flattened or gently convex to the antero-lateral margins and somewhat abruptly curved towards the opposite valve as it approaches the postero-lateral margins, along the median line the surface is gently convex from the beak to near the anterior margin where it is abruptly curved towards the opposite valve; mesial sinus originating near the middle of the valve as a shallow, flattened depression which becomes gradually deeper anteriorly, towards the front it curves abruptly towards the opposite valve and is produced in a broad, flat, lingual extension whose surface lies in nearly a right angle to the plane of the valve and whose front margin is deeply serrate; the beak is small, sharply pointed, moderately incurved and rather conspicuously extended beyond the opposite valve posteriorly; the delthyrium is broadly triangular, the deltidial plates and foramen not observed; the plications rounded or subangular, simple, originating at the beak, about seven usually present in the sinus and about seven or eight upon each lateral slope, towards the anterior margin of the valve they are frequently marked by a faint median longitudinal groove. Internally the hinge-teeth are supported by dental lamellæ which extend from one-fourth to one-third the length of the valve anteriorly from the beak.

Brachial valve much more convex than the pedicle, becoming gibbous in front, flattened in the umbonal region and sometimes with a slight, longitudinal, median depression, the surface sloping with a long, gently convex curvature to the front, the lateral portions of the valve strongly convex longitudinally the anterior curvature being more abrupt, and curving abruptly to the lateral margins; mesial fold obsolete in the posterior half of the valve and only moderately elevated above the lateral slopes in front; the beak strongly incurved beneath that of the opposite valve; the plications similar in form and number to those of the opposite valve, and frequently grooved in a similar manner towards the anterior margin. The internal characters of the species are not sufficiently well known, but the cardinal process seems to be absent, and the hinge-plate seems to be undivided, a median septum is present which is divided posteriorly, each division supporting one side of the hinge-plate, the cavity between the divisions of the septa apparently does not form an open crural

cavity, but is covered by the median portion of the hinge-plate, being open only towards the front, the median septum continues anteriorly from the beak for about one-fourth the length of the valve.

The fine surface markings are obscure upon all specimens examined, but occasional, rather inconspicuous concentric lines of growth are present towards the anterior margin. The shell structure is finely punctate.

Remarks.—In general form this species approaches very closely to *R. cooperensis*, the most conspicuous difference being in its somewhat finer plications, and even in this character it grades into the other. The two forms should perhaps be considered as synonyms, but the only typical representatives of *R. persinuata* have been found at a somewhat higher geological horizon than the typical *R. cooperensis*, and the two forms have in consequence been considered as distinct. Furthermore the punctate shell structure has not been actually observed in *R. cooperensis*. The shell which was described by Miller as *Camarophoria occidentalis* from Lake Valley, New Mexico, is clearly identical with *R. persinuata*. Authentic examples of Miller's species from the typical locality exhibit none of the characters of *Camarophoria*, but they do agree in all respects with authentic specimens of Winchell's species. The punctate structure of the shell is commonly obscure and frequently cannot be detected at all. The type of the species is an internal cast in a rather coarse dolomitic material, which is incapable of preserving such characters, but in one specimen from the Fern Glen formation of St. Louis County, Missouri, the punctation of the shell can be clearly seen on parts of the surface. The specimen, which exhibits this character best, is one of those from Lake Valley, New Mexico. The internal characters of the rostral portion of the brachial valve have not been observed by sectioning authentic specimens from the typical locality, both because such specimens are too uncommon and because their condition of preservation is not favorable. One excellent internal cast of this portion of the shell from the typical locality, clearly shows, however, the presence of the undivided hinge-plate which is characteristic of the genus. The median septum divided posteriorly is also clearly shown in this specimen, but the divisions of the septa seem to give support to the hinge-plate to a point somewhat farther anterior in position than in *R. cooperensis*, but such a character may be expected to vary even within a single species.

Horizon.—Kinderhook.

RHYNCHOPORA ? COOPERENSIS (Shumard)

Plate XXX, Figs. 7-15; ? 22-25

1855. *Rhynchonella Cooperensis* Shum., I and II Rep. Geol. Surv. Mo., p. 204, pl. C, figs. 4a-d.
1894. *Rhynchonella cooperensis* Keyes, Mo. Geol. Surv., vol. 5, p. 101.
1910. *Rhynchopora ? cooperensis* Weller, Bull. Geol. Soc. Am., vol. 21, p. 515, fig. 18.

Description.—Shell usually below medium size, broader than long, the postero-lateral margins meeting at the beak in an obtuse angle, the lateral margins rounded and the anterior margin nearly straight. The dimensions of a rather small but nearly complete specimen are: length 14.6 mm., width 17 mm., thickness 12 mm., width of sinus in front 9.5 mm.

Pedicle valve depressed convex in the posterior half and flattened or gently convex to the antero-lateral margins, along the median line the surface is gently convex to near the anterior margin of the shell where it is strongly curved towards the opposite valve, along the postero-lateral margins towards the beak, the edge of the valve is inflected towards the opposite valve; mesial sinus originating near the middle of the valve as a shallow, flattened depression, it is but little depressed to near the anterior margin of the valve where it is rather abruptly and strongly curved

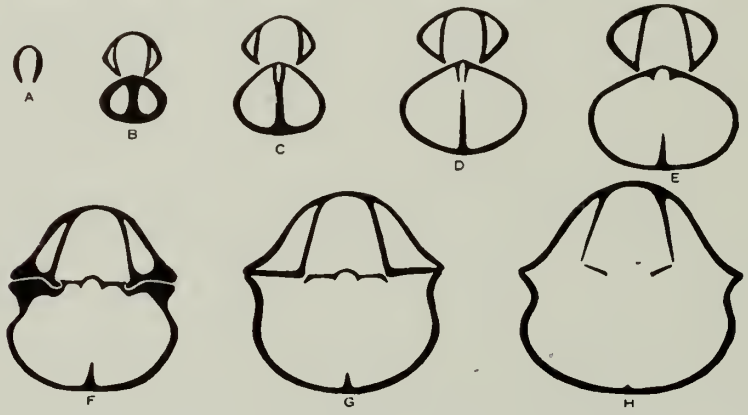

FIG. 22.—A series of eight cross-sections of the rostral portion of the shell of *Rhynchopora ? cooperensis* (× 2½), showing the undivided hinge-plate, and the consequently covered crural cavity.

towards the opposite valve and produced in a broad lingual extension whose surface lies in nearly a right angle to the plane of the valve, and which is deeply serrate at the distal line of junction with the opposite valve; beak rather small, pointed, slightly incurved, rather conspicuously protuberant beyond that of the opposite valve, pierced by a small, subcircular foramen; delthyrium broadly triangular and communicating with the foramen at its apex, the deltidial plates not observed; plications subangular or rounded, simple and originating at the beak, from four to six occupy the sinus with about six others upon each lateral slope and sometimes one or two very faint ones towards the postero-lateral margins, the plications of the sinus are sometimes medially grooved towards the front. Internally the hinge-teeth are supported by dental lamellæ which extend anteriorly from the beak for about one-fourth or more of the length of the valve.

Brachial valve much more strongly convex than the pedicle, becoming ventricose towards the front, the umbonal region mesially flattened or with a shallow, longitudinal depression which sometimes continues to the front of the valve, the surface sloping with an increasing curvature from the point of greatest curvature to the beak, and with a short and rather abrupt curvature to the front, the lateral slopes gently convex on either side of the fold and then curving abruptly to the margin both laterally and anteriorly; the mesial fold obsolete in the posterior half of the shell and only moderately elevated above the lateral slopes in front; beak broadly pointed and strongly incurved beneath that of the opposite valve; plications similar in form and number to those of the opposite valve, those of the lateral slopes strongly arched longitudinally and sometimes with a slight median groove in front. Internally the cardinal process is wanting; the hinge-plate is undivided but with the transversely convex median portion differentiated from the lateral portions anteriorly, at the apex of the beak a median septum divided above supports the initial portion of the hinge-plate, but the connection between the septum and the hinge-plate is very short and the septum itself rapidly becomes lower and disappears at about one-fourth the length of the valve from the beak, the lateral portions of the hinge-plate are produced anteriorly into the crura.

Surface of both valves marked by fine, more or less regular, concentric striæ and by occasional stronger lines of growth, the growth lines being more conspicuous towards the anterior margin. The shell structure probably punctate.

Remarks.—This species is referred with a query to the genus *Rhynchopora*, because the punctate shell structure has not been observed. The character of the hinge-plate of the brachial valve, undivided as it is to the crural bases, agrees with the structure found in *Rhynchopora*, this undivided hinge-plate being unknown in any other of our Mississippian rhynchonelloid shells. The species most closely resembles *R. persinuata* in which the punctate structure of the shell has been clearly observed, and it is possible that the two forms should really be considered as synonyms. The relationships of these two species have been fully considered in the discussion of *R. persinuata*.

Horizon.—Kinderhook and base of Burlington limestone.

Rhynchopora ? rowleyi n. sp.

Plate XXX, Figs. 18-21

1908. *Pugnax missouriensis* ? Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 81, pl. 17, figs. 60-62.

Description.—Shell of about medium size, wider than long, transversely subelliptical in outline, the greatest width near the mid-length, the

postero-lateral margins a little concave, meeting at the beak in an obtuse angle, the lateral margins rounded, the anterior margin emarginate. The dimensions of a nearly perfect specimen, the holotype, are: length of pedicle valve 18 mm., length of brachial valve 17.8 mm., greatest width 23.2 mm., thickness 15.6 mm., width of sinus in front 13.3 mm.

Pedicle valve depressed convex, the greatest depth being posterior to the middle near the umbonal region, the surface curving gently to the antero-lateral and lateral margins, becoming more strongly convex to the postero-lateral and cardinal margins; mesial sinus originating near or a little back of the middle of the valve, broad and shallow at first, becoming rapidly deeper towards the front where it is produced in an elongate and broad lingual extension directed at about a right angle to the plane of the valve and with a strongly serrate anterior margin; beak small, sharply pointed, moderately incurved and coming nearly in contact with the umbo of the opposite valve; the delthyrium broadly triangular, nearly filled by the beak of the opposite valve. The simple plications are rounded posteriorly, becoming more subangular anteriorly, seven or eight occupy each lateral slope of the valve and six the mesial sinus. Internally the hinge-teeth are supported by strong dental lamellæ which diverge a little more widely than the lateral margins of the sinus and extend anteriorly more than one-third the length of the valve.

Brachial valve strongly convex, the greatest depth anterior to the middle, the surface curving abruptly to the antero-lateral, lateral, and postero-lateral margins, becoming inflected to the cardinal extremities; mesial fold originating near the middle of the valve, flattened on top, becoming only moderately differentiated from the general curvature of the valve towards the front; the umbonal region prominent, the beak strongly incurved beneath that of the opposite valve. The plications more angular than those of the opposite valve and alternate with them, those reaching the antero-lateral margins being distinctly grooved along their median line for some distance back from the margin. The internal characters of the valve are not sufficiently known, but a thin median septum is present which reaches nearly to the middle of the valve.

The finer surface markings are not well preserved upon the specimen here described, but they apparently consist of rather fine and somewhat irregular concentric lines of growth which become a little stronger and more crowded towards the front. No punctate shell structure has been observed.

Remarks.—Judging from its external characters alone this species seems to be congeneric with *R. persinuata*, and the character of the dental lamellæ of the pedicle valve and the median septum of the brachial valve also agree with that species. It is not known, however, that the brachial valve possesses an undivided hinge-plate covering the crural cavity, a feature which is characteristic of *R. persinuata* and other species which

have been included in the genus *Rhynchopora* in this volume. The apparent absence of any indication of punctate shell structure is opposed to the inclusion of the present species in *Rhynchopora*, but this feature is likewise very obscure in *R. persinuata*, having been observed, indeed, in only a few individuals, and even in those it is not always beyond question, while in *R. cooperensis*, another closely allied species, the punctate shell structure has never been observed. For the present, therefore, the species will be included in *Rhynchopora* with a query. The species differs from *R. persinuata* in its somewhat greater proportionate width and consequent coarser plications which are separated by relatively shallower and broader furrows. The anterior lingual extension of the pedicle valve is also distinctly concave transversely in the type, giving to the anterior margin of the shell a distinctly emarginate outline, while in *R. persinuata* this lingual extension is flat and the anterior margin of the shell consequently straight.

Horizon.—Louisiana limestone.

Rhynchopora ? perryensis n. sp.

Plate XXV, Figs. 18-21

Description.—Shell small, broadly subovate in outline, usually a little wider than long, the greatest width near the mid-length of the shell, the postero-lateral margins nearly straight and meeting at the beak in an angle of from 105 to 110 degrees, the antero-lateral and anterior margins rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 10.2 mm., length of brachial valve 9.2 mm., greatest width 10.5 mm., thickness 8 mm., width of sinus in front 7.1 mm.

Pedicle valve convex in the umbonal region, rather narrowly rounded transversely across the median line with the surface gently convex to the antero-lateral margins and curving abruptly to the postero-lateral margins, from the beak to the anterior margin along the median line the surface describes nearly a semicircular curve; mesial sinus originating near the middle of the valve, nearly flat or slightly convex transversely in the bottom, produced anteriorly in a rounded lingual extension of greater or less length; beak sharply pointed and strongly incurved, the apex coming in contact with the umbo of the opposite valve, the delthyrium hidden by the incurvature of the beak; plications simple, obsolete towards the beak but originating in the umbonal region, they are low and broadly rounded posteriorly, becoming more angular towards the front, two or three, rarely four, occupy the bottom of the mesial sinus, the sloping sides of the sinus being entirely nonplicate; upon each lateral slope of the valve are from four to six plications which grow successively smaller towards the cardinal extremities, the last one or two being very

faint; fine, regular, concentric lines of growth cover the entire surface of the valve, becoming somewhat stronger towards the outer margin. Internally the dental lamellæ are short.

Brachial valve much more strongly convex than the pedicle, the greatest convexity near the anterior margin, the surface sloping with a long, gently convex curve from the point of greatest elevation to the beak, a portion of this slope in the middle part of the valve being nearly straight, along the median line in the umbonal region towards the beak, the surface is a little impressed in a slight median sinus, the slopes from the median line to the lateral margins of the valve are convex and rather abrupt, with a slight interruption in the slope anteriorly at the lateral borders of the mesial fold; mesial fold originating near the middle of the valve, not strongly differentiated from the general convexity except near the anterior margin; the beak strongly incurved beneath that of the opposite valve; the plications entirely similar in form and number to those of the opposite valve, and alternate with them, and the concentric lines of growth also similar. Internally a thin median septum is present in the rostral portion of the valve which divides internally and is joined to the two lateral divisions of the hinge-plate, the resulting crural cavity being very broad and shallow. The hinge-plate apparently divided. Shell structure minutely punctate.

Remarks.—The specimens originally used in the description of this species were collected by Mr. D. K. Greger at Landing No. 76, Perry County, Missouri. Since the description was written, however, some excellent examples of the species have been collected from the Okaw limestone of the Chester group in Randolph County, Illinois, which clearly exhibit a distinctly punctate shell structure. A re-examination of the Perry County examples has led to the detection of the same structure upon these specimens, although it is very obscure and has been almost entirely obliterated in the process of fossilization. The punctate shell structure in a rhynchonelloid shell is characteristic of *Rhynchopora*, in which genus the species is here placed, although it differs in some particulars from other species which have been included in this genus in this report. In all the other species of *Rhynchopora* here recognized,, the hinge-plate of the brachial valve is undivided, the crural cavity being inclosed above, but in this species the hinge-plate is apparently divided. It is, of course, possible that the median plate joining the two sides of the hinge-plate was very delicate and easily injured, and that it has been destroyed in the few specimens which have been ground down, but this is not likely, since all of the specimens so examined have been shells with both valves in articulation. So far as it is known, the internal characters of the species are identical with those of *Camarotœchia*. Another character in which this species differs from other members of the genus *Rhynchopora* here recognized, is the obsolescence of the plications in the posterior portion

of the shell, in this respect simulating the genera *Pugnax* and *Pugnoides*. In fact, were it not for the punctate shell structure the species would be placed in the genus *Pugnoides* without hesitation. It is possible, of course, that more than one generic group of rhynchonelloid shells developed the punctate structure, and that all such shells should not be referred to *Rhynchopora*, but until the internal characters of the genotype have been determined, it seems unwise to erect any additional genera.

Horizon.—Okaw limestone of the Chester group.

Family CENTRONELLIDÆ

Genus *CENTRONELLA* Billings

Description.—Shell small, rostrate, plano-convex or concavo-convex, with smooth valves. Pedicle valve with a median, longitudinal ridge from which the surface slopes more or less abruptly to the lateral margins, the beak acute and incurved, perforated at its apex by a subcircular foramen, the delthyrium closed by a pseudodeltidium. Brachial valve concave transversely by reason of the presence of a median sinus which is not apparent on the interior, the beak small, not incurved. Internally the dental sockets are broad, bounded interiorly by the high walls of the hinge-plate. This plate is divided medially by a deep furrow extending to the apex, and, therefore, consists of two processes which are elevated, thickened and rest on the bottom of the valve. From the anterior face of these arise the crura which converge for a short distance, and expand to form two broad, acute jugal processes. From here the lateral branches of the brachidium curve outward, gradually turning from a vertical to a horizontal position, broaden rapidly and unite to form an anterior triangular plate which bears a median ridge where the two lateral branches are conjoined.

Remarks.—The species which are here referred to the genus *Centronella* are so placed because of external form alone. The description of the brachidium given above is from the work of Hall and Clarke, and it is by no means certain that the characters of these Mississippian species conform to the definition of the genotype.

Centronella louisianensis n. sp.

Plate XXX, Figs. 26-29

Description.—Shell minute, subovate in outline, longer than wide, the greatest width anterior to the mid-length, the anterior and antero-lateral margins describing nearly a semicircle or slightly truncated in front, the postero-lateral margins nearly straight or gently convex, meeting at the beak in an acute angle. The dimensions of a perfect specimen are: length of pedicle valve 2.9 mm., length of brachial valve 2.5 mm., width 2.7 mm., thickness 1 mm.

Pedicle valve longitudinally subcarinate, with the lateral slopes gently convex, the curvature becoming more abrupt towards the cardinal margins, the margins incurved between the cardinal extremities and the apex of the beak to form a small pseudo-cardinal area lying in nearly the plane of the valve, the valve arched from beak to front along the median line with the curvature somewhat more abrupt posteriorly, the greatest depth of the valve posterior to the middle; the beak prominent, acutely pointed, very slightly incurved, projecting notably beyond that of the opposite valve; delthyrium broadly triangular, partially closed by a pair of deltidial plates which do not meet at the median line, thus leaving a triangular foramen which reaches from the apex to the base.

Brachial valve less convex than the pedicle, greatest depth posterior to the middle, the surface curving more abruptly to the cardinal margins; beginning just in front of the umbonal region a shallow, sub-angular or rounded mesial sinus, with ill-defined lateral margins, continues with increasing depth to the front margin; lateral slopes of the valve convex transversely from the median line to the lateral margins; beak obtusely pointed, scarcely or not at all incurved.

Surface of both valves nearly smooth, marked only by more or less inconspicuous concentric lines of growth which are sometimes nearly obsolete.

Remarks.—This little shell resembles the associated *Trigeria curreyi* in size and general form, but differs from it in the absence of plications and commonly in the less angular median sinus of the pedicle valve. In its smooth shell it resembles the associated *Selenella pediculus,* but may be easily distinguished from it by its subcarinate pedicle valve, its sinuate brachial valve, and by the more conspicuous concentric lines of growth. The species is referred to the genus *Centronella* because of its external form alone, the internal characters of neither valve being known, nor has the punctate structure of the shell been detected.

Horizon.—Louisiana limestone of the Kinderhook.

Centronella (?) emaciata Rowley
Plate XXX, Figs. 40-42

1900. *Centronella emaciata* Rowley, Am. Geol., vol. 25, p. 265, pl. 5, figs. 48-50.

Description.—Shell small, longer than wide, ovate-subpentagonal in outline, the greatest width posterior to the mid-length; the posterior lateral margins nearly straight and meeting at the beak in an angle of about 80 degrees, posteriorly the margins round rather abruptly into the gently convex antero-lateral margins which in turn pass gradually into the rather short but more convex anterior margin. The dimensions of the holotype are: length of pedicle valve 12.3 mm., length of brachial valve 11.2 mm., greatest width 9.8 mm., thickness 4.1 mm.

Pedicle valve with its greatest depth a little posterior to the middle, subcarinate along the median region from the beak nearly to the front margin, on either side of the rather narrowly rounded median region the surface slopes to the extreme lateral extremities with a gently concave curvature producing a compression of the valve in that direction, near the postero-lateral margins the surface is abruptly curved towards the opposite valve, becoming inflected to the cardinal extremities, from the highest point to the front margin the surface is gently convex and to the beak a little less gently convex; mesial sinus absent, the subcarinate median portion of the valve simulating a mesial fold; the beak acutely pointed, strongly protuberant beyond that of the opposite valve, nearly erect, the foramen not clearly shown in the type but apparently small and encroaching upon the umbonal region, the characters of the delthyrium and pseudodeltidium hidden in the specimen. Internally a pair of dental lamellæ extend anteriorly from the beak for about one-fifth the length of the valve with a very narrow angle of divergence.

Brachial valve much flattened, less convex than the pedicle, the greatest depth posterior to the middle, the surface very gently convex to the antero-lateral and anterior margins, curving more abruptly to the postero-lateral margins, especially as it approaches the margin; mesial fold or sinus absent; the beak moderately incurved, passing beneath the delthyrium of the opposite valve.

Shell structure minutely punctate.

Remarks.—In general outline this shell resembles *Centronella alveolata* Hall from the Onondaga limestone of New York, but it is a smaller and much thinner shell with the pedicle valve less arcuate and without a median sinus in the brachial valve. The internal characters of this species, aside from the dental lamellæ of the pedicle valve, are unknown, though it can be affirmed that no median septum is present in the brachial valve, that valve being so exfoliated in the type specimen that it would be clearly shown if present. The species is quite certainly not a true *Centronella,* because in all cases where the form of the brachidium is known among these shells, important modifications in the Centronella type of loop have become fixed before the beginning of Mississippian time but without a knowledge of the characters of the brachidium, it is unwise to propose a new generic division, and the species is allowed to rest in *Centronella* with a query.

Horizon.—Burlington white chert.

Genus *SELENELLA* Hall

Description.—Shell small, terebratuliform, with biconvex, smooth valves, subovate in outline. Internally the brachidium is centronelliform, but

without anterior or posterior prolongation, and without the thickening along the symphysis of the lateral elements.

Remarks.—The only species of this genus recognized in our faunas is so small that it has been impracticable to study its internal characters by means of serial sections as has been done in the case of the larger forms, but the centronellid character of the brachidium has been detected in one specimen which is filled with translucent, crystalline calcite.

Selenella pediculus (Rowley)

Plate XXX, Figs. 34-39

1901. *Diclasma (?) pediculus* Rowley, Am. Geol., vol. 27, p. 350, pl. 28, figs. 43-45.

1908. *Diclasma (?) pediculus* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 80, pl. 17, figs. 57-59.

Description.—Shell minute, smooth, subovate in outline, longer than wide, the greatest width near or posterior to the mid-length, the anterior margin regularly rounded or slightly truncated in the middle, pointed posteriorly. The dimensions of a large example are: length of pedicle valve 4 mm., length of brachial valve 3.5 mm., greatest width 3.2 mm., thickness 1.5 mm.

Pedicle valve arched from beak to front with the curvature a little more abrupt to the posterior extremity, also arched transversely with the lateral slopes a little flattened, the greatest convexity of the valve near the middle, the surface incurved towards the cardinal extremities to form a small, pseudo-cardinal area; mesial portion of the valve not differentiated except sometimes a little flattened anteriorly; the beak prominent, pointed, slightly incurved, projecting conspicuously beyond that of the opposite valve; delthyrium large, broadly triangular, partially closed by a pair of deltidial plates which sometimes meet towards the base of the delthyrium, but often failing to meet and so leaving a triangular opening from the apex to the base, the foramen slightly or not at all encroaching upon the beak of the valve.

Brachial valve depressed convex, its depth about one-half that of the pedicle valve, the surface curving more abruptly towards the cardinal margin; mesial portion of the valve not distinctly differentiated, although it is rather broadly flattened; the beak short, obtusely pointed, incurved beneath the delthyrium of the opposite valve. Internally the brachidium is centronelloid in form, without anterior or posterior prolongation, being essentially of the type characteristic of the genus *Selenella.*

Surface of both valves usually entirely smooth, when lines of growth are present they are very faint and are restricted to the marginal portion.

Remarks.—The brachidium has been observed in but a single example of this shell, the interior of which specimen is filled with nearly transparent calcite. In this specimen the brachidium is apparently complete and seems to agree with that of the genus *Selenella*, with which genus the external form of the shell also conforms. In some respects these little shells have the appearance of young individuals; this is especially true in the almost complete absence of concentric lines of growth and in the immature condition of the pseudodeltidium, the small size is also indicative of immaturity, but there is no larger species of loop-bearing shells associated with this one in the Louisiana limestone fauna, of which it might be the immature representative. The specimen whose dimensions have been given above is the largest one observed by the writer, the smaller ones are 1 mm. or less in length, with all gradations between, the specimen in which the brachidium has been observed being one of the larger ones.

Horizon.—Louisiana limestone.

Genus *TRIGERIA* Bayle

Description.—Shell small, centronelliform, with subplano-convex valves, marked with simple, radiating plications. Internally the brachial valve has an undivided, tripartite hinge-plate, the median division being perforated near the apex. The brachidium as in *Centronella* but with a smaller anterior plate.

Remarks.—The internal characters of the single member of this genus here recognized, are not known, so that it is not possible to determine whether or not it is truly congeneric with *Trigeria guerangeri*, the genotype. It is, however, a plicated centronelliform shell and may be retained in this genus where it was originally placed, until a knowledge of its internal characters shall prove that it belongs elsewhere.

Trigeria (?) curriei Rowley

Plate XXX, Figs. 30-33

1901. *Trigeria (?) currici* Rowley, Am. Geol., vol. 27, p. 350, pl. 28, figs 40-42.

1908. *Trigeria (?) currici* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 80, pl. 17, figs. 54-56.

Description.—Shell minute, plicated, subovate in outline, longer than wide, the greatest width near or in front of the middle, the anterior and antero-lateral margins subsemicircular, acutely pointed posteriorly. The dimensions of a perfect specimen are: length of pedicle valve 2.7 mm., length of brachial valve 2.5 mm., greatest width 2.2 mm., thickness 1 mm.

Pedicle valve subcarinate along the median line, especially towards the front, arched from beak to front with the curvature a little more abrupt posteriorly, the lateral slopes gently convex from the median line to the lateral margins; the margins of the valve between the cardinal extremities and the apex of the beak inflected to form a slight pseudocardinal area which lies in nearly the plane of the valve; the beak prominent, acutely pointed, very slightly incurved; delthyrium rather broadly triangular, partially closed by a pair of deltidial plates which do not come in contact along the median line, thus leaving a triangular foramen which reaches from the apex of the delthyrium to the base.

Brachial valve less convex than the pedicle, with the greatest convexity posterior to the middle; an angular or subangular median sinus originates in or just in front of the umbonal region and continues to the front margin with increasing depth, the lateral margins of the sinus not defined; the lateral slopes of the valve from the median line to the lateral margins of the valve are transversely convex with the curvature a little more abrupt towards the lateral margins, especially near the cardinal extremities; beak obtusely pointed, scarcely or not at all incurved.

Surface of both valves marked by from eight to twelve rather broad, rounded, simple plications which originate in the umbonal region and increase in strength anteriorly, and by several more or less indistinct lines of growth which are sometimes nearly or quite obsolete.

Remarks.—The internal characters of neither valve of this species have been observed, so that the form of brachidium, if such a structure be present, is not known. Neither has the punctate shell structure been certainly determined. In its external features the general form of the shell is notably centronelloid, and being plicated it is placed in the genus *Trigeria* where it was first located by Rowley, the author of the species. The specimen whose dimensions have been given above is perhaps of average size, the larger examples attain a length of 4 mm. or more.

Horizon.—Louisiana limestone.

Family TEREBRATULIDÆ

Genus *CENTRONELLOIDEA* n. gen.

Description.—Shell small, centronelliform, with smooth valves, subovate to subcuneate in outline. Pedicle valve with a longitudinal median ridge from which the lateral surfaces slope rather abruptly to the margins, the beak acuminate and moderately incurved, with a circular foramen at the apex, the delthyrium closed by the pseudodeltidium. Internally the dental lamellæ are well developed but are of only moderate length. The brachial valve much shallower than the pedicle with a longitudinal median sinus. Internally the hinge plate is divided medially, the two lateral divisions being supported by a pair of septa which rise from the

floor of the valve at either side of the median line, these septa continue as crural lamellæ anteriorly beyond the articulation of the valves and their inner margins are continued into the crura. The brachidium is short, not

FIG. 23.—A series of six cross-sections of the rostral portion of the shell of *Centronelloidea rowleyi* (× 2½), showing the dental lamellæ of the pedicle valve, and the crural lamellæ of the brachial valve which support the divided hinge-plate, posteriorly.

reaching beyond the middle of the shell, and like that of *Diclasma* in form, but with much less widely diverging primary lamellæ.

Remarks.—In its external form this genus is like *Centronella*, but its brachidium is essentially like that of *Diclasma*, although the development of the crural lamellæ in the rostral portion of the brachial valve is entirely different from that genus. The arrangement of these lamellæ more nearly resembles the condition in *Diclasmoides*, but the plates supporting the inner margins of the lateral divisions of the hinge-plate continue further anteriorly, forming a free V-shaped cavity beyond the articulation of the valves, and the inner margins of the walls of this cavity give origin to the crura. The external form of the shell is entirely different from either *Diclasma* or *Diclasmoides*.

CENTRONELLOIDEA ROWLEYI (Worthen)

Plate XXXI, Figs. 5-15

1884. *Terebratula rowleyi* Worthen, Bull. No. 2, Ill. State Mus Nat. Hist., p. 23.
1890. *Terebratula rowleyi* Worthen, Geol. Surv. Ill., vol. 8, p. 102, pl. 11, figs. 6-6b.
1894. *Terebratula rowleyi* Keyes, Mo. Geol. Surv., vol. 5, p. 105, pl. 41, fig. 23.
1897. *Diclasma ? rowleyi* Schuchert, Synop. Am. Foss. Brach., p. 213.

Description.—Shell small, centronelliform, longer than wide, the greatest width anterior to the mid-length of the shell, ovate-subcuneate in outline, the postero-lateral margins a little concave and meeting at the beak in a very acute angle, the antero-lateral and anterior margins regularly rounded or the anterior margin somewhat truncate. The dimensions of two nearly perfect specimens, metatypes, are: length of pedicle valve 10 mm. and 9.2 mm., length of brachial valve 9 mm. and 8 mm., greatest width 7.7 mm. and 7.8 mm., thickness 5 mm. and 4.8 mm.

Pedicle valve most convex posterior to the middle, narrowly rounded transversely across the median line in the posterior portion, with the lat-

eral slopes gently convex and dropping abruptly to the cardinal extremities, anteriorly the valve gradually becomes more broadly rounded transversely with less steeply sloping sides, until at the front it is nearly regularly rounded from side to side; mesial sinus wanting; the beak prominent, acuminate, conspicuously produced posteriorly and not incurved; the delthyrium rather large, closed with a pseudodeltidium, the foramen of moderate size, encroaching upon the umbonal region, in contact with the delthyrium only at its apex.

Brachial valve much shallower than the pedicle, conspicuously sinuate, the sinus originating at the beak and rapidly broadening anteriorly until it occupies nearly the entire width of the valve in front, the most convex portions of the valve are the regions between the median line and the postero-lateral margins, from which regions the surface curves rather abruptly to the cardinal extremities and less abruptly to the lateral margins anteriorly; the beak acutely pointed and incurved beneath the margin of the pseudodeltidium of the opposite valve.

Surface of both valves smooth, ordinarily not even exhibiting any lines of growth; the shell structure finely punctate.

Remarks.—This species has been incorrectly identified by Hall and Clarke[1] and their reference of it to the genus *Diclasma* is erroneous, although the specimen they have illustrated is a *Diclasma*, and possibly *D. formosa*. The true shell to which the name *Terbratula rowleyi* was originally applied is more nearly allied to *Centronella* in external contour than to *Dielasma*. The species is conspicuously centronelliform in its external configuration, although it is somewhat thinner with much less incurved pedicle beak than *C. glans-fagea* the genotype.

Horizon.—Burlington white chert.

Genus *CRANENA* Hall and Clarke

Description.—Shell terebratuliform. Pedicle valve with or without a median sinus, and with well-developed, dental lamellæ of moderate length, the foramen large, oblique, and encroaching upon the umbonal portion of the valve, the beak incurved. Brachial valve without median fold, even in those species with a well-defined sinus in the opposite valve, but sometimes with a slight mesial depression near the front margin; internally the well-developed socket plates are connected transversely by a concave hinge-plate which is perforated at the apex of the valve posteriorly, upon the inner or concave surface of the hinge-plate a pair of ridges originate at or near the anterior margin of the perforation and continue anteriorly across the plate from the front of which they are produced into the crura, these crural ridges upon the hinge-plate divide that

[1] Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 27-28. (1894.)

plate into three subequal parts or into two equal lateral divisions and a broader central one, and in some species the crural ridges are accompanied by similar ridge-like thickenings upon the opposite side of the hinge-plate. The brachidium is short and Dielasma-like, not reaching to the middle of the valve.

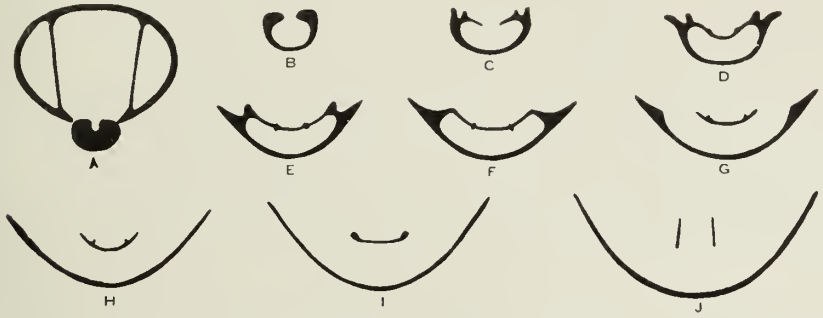

FIG. 24.—A series of ten cross-sections of the rostral portion of the shell of *Cranæna iowensis* (× 2½), only one of which (A) shows the pedicle valve with the dental lamellæ. In the brachial valve is shown the concave hinge-plate, perforated posteriorly, with the crural ridges passing anteriorly into the crura.

Remarks.—This genus differs fundamentally from *Dielasma* in the origin of the crura from the thickened crural ridges of the hinge-plate, rather than from the crural lamellæ resting upon the inner surface of the valve, and in the absence of a special plate in the brachial valve for muscular attachment, the muscles being attached directly to the inner surface of the valve. From *Girtyella* the genus may be distinguished by the absence of a median septum in the brachial valve and by the origin of the crura from crural ridges on the hinge-plate rather than from the anterior extension of the inner extremities of the socket plates.

CRANÆNA GLOBOSA n. sp.

Plate XXXIV, Figs. 60-66

1895. *Dielasma Burlingtonensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 9-11.

1895. *Dielasma formosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 14-15 (not figs. 12-13, 16-26).

Description.—Shell small, subovate in outline, longer than wide, the greatest width near the mid-length, the valves subequally convex. The dimensions of two complete examples are: length of pedicle valve 14 mm. and 10.5 mm., length of brachial valve 12 mm. and 9.1 mm., greatest width 10.3 mm. and 8 mm., thickness 9.4 mm. and 5.8 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, arched from beak to front along the median line with the curvature becoming regularly more convex posteriorly, the surface curving abruptly from the median line towards the postero-lateral margins and becoming inflected towards the cardinal extremities, curving more gently to the antero-lateral and anterior margins; mesial sinus obsolete and the mesial portion of the valve not differentiated from the lateral slopes; the beak prominent, incurved, pierced by a subcircular foramen which encroaches wholly upon the umbonal portion of the valve, only coming in contact with the delthyrium at its apex; delthyrium largely occupied by the incurved beak of the opposite valve, the remaining space closed by the deltidial plates. Internally the dental plates are well developed and extend anteriorly from the beak for nearly one-fourth the length of the valve; the muscular scars obscure or obsolete in smaller specimens, but

Fig. 25.—A series of six cross-sections of the rostral portion of the brachial valve of *Cranæna globosa* (× 2½), showing the concave hinge-plate which is perforated posteriorly, and the crural ridges upon the hinge-plate.

on the internal casts of larger and older examples they are suggested by more or less indefinite markings radiating from the beak.

Brachial valve a little less convex than the pedicle, the greatest convexity near the middle, the surface regularly arched from beak to front along the median line with the curvature a little more convex posteriorly, from the mesial line the surface is rather abruptly curved to the postero-lateral margins and somewhat more gently to the antero-lateral and anterior margins; the mesial portion of the valve not differentiated from the lateral slopes; beak acutely pointed, incurved beneath the base of the pseudodeltidium of the opposite valve. Internally the socket plates are joined transversely by an elongate, concave hinge-plate which is perforated at its apex, anteriorly beyond the articulation of the valves the lateral attachments of the hinge-plate to the inner surface of the shell retreat from the lateral margins of the valve and these continuations of the socket plates are reduced to mere ridges between which, upon the concave side of the hinge-plate, a pair of crural ridges originate; the crural ridges diverge anteriorly and are produced into the bases of the crura, they are still connected transversely by the anterior extremity of the hinge-plate after connections with the inner, lateral surfaces of the valve have disappeared; the brachidium is short and Dielasma-like with rather widely divergent descending lamellæ and sharply recurved ascending lamellæ.

Surface of both valves marked only by concentric lines of growth which vary in the strength of their development. Shell structure finely and closely punctate.

Remarks.—This is a small species and may be easily recognized by its more or less rotund form and by the absence of fold or sinus. Specimens of it have sometimes been identified as *Diclasma formosa*, but besides being entirely different from *Diclasma* in the essential characters of the interior of the rostral portion of the brachial valve, it is a comparatively broader shell with the valves more regularly arched transversely. The species shows considerable variation in outline, especially in the position of the line of greatest width, it being sometimes anterior and sometimes posterior to the mid-length; it also varies in the convexity of the valves, in some old individuals becoming ventricose. The species never attains a great size, about 17 mm. being the maximum length which has been observed.

Horizon.—Burlington limestone.

Cranæna sulcata n. sp.

Plate XXXIV, Figs. 55-59

1895. *Diclasma turgida* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 1-3 (not figs. 4-8).

Description.—Shell small, ovate, subpentagonal in outline, the anterior margin emarginate, longer than wide, the greatest width near the mid-length of the shell. The dimensions of a nearly perfect individual are: length of pedicle valve 11 mm., length of brachial valve 9.2 mm., greatest width 8.8 mm., thickness 8.1 mm.

Pedicle valve strongly convex, the greatest convexity near or posterior to the middle, the surface almost regularly arched from the beak to the front or with the curvature a little more convex posteriorly, the surface curving abruptly to the lateral margins becoming inflected to the cardinal extremities; mesial sinus originating near the middle of the valve, rather narrow or of moderate width, rounded in the bottom, sometimes becoming deep at the anterior margin, its lateral margins rounding into the lateral slopes of the valve without sharp demarcation; the beak pointed, rather strongly incurved, perforated by a subcircular foramen which encroaches wholly upon the umbonal region, coming in contact with the delthyrium only at its apex; delthyrium broadly triangular, closed by deltidial plates throughout, except as it is filled with the beak of the opposite valve. Internally the dental lamellæ are well developed and of moderate length.

Brachial valve a little less convex than the pedicle, the greatest convexity near the middle, the surface arched from beak to front along the median line with the curvature sometimes more abrupt posteriorly and sometimes anteriorly, the curvature to the lateral margins rather abrupt;

the median portion of the valve undifferentiated from the general convexity of the valve or rather indefinitely flattened towards the front, never depressed in a mesial sinus or elevated in a fold; beak prominent and incurved beneath that of the opposite valve. Internally the socket plates are joined transversely by an elongate, concave hinge-plate which is perforated at the apex, anteriorly the socket plates are reduced and the lat-

Fig. 26.—A series of ten cross-sections of the rostral portion of the shell of *Cranæna sulcata* (× 2½), showing the hinge-plate perforated posteriorly, and the crural ridges.

eral attachments of the hinge-plate to the inner surface of the valve retreat from the lateral margins, a pair of ridges diverge anteriorly from near the apex upon the concave surface of the hinge-plate, which become the bases of the crura, the concave hinge-plate continues to join the crural bases after their lateral connection with the inner surface of the valve has become discontinued; complete brachidium not known, but it is believed to be short and Dielasma-like in form.

Remarks.—This species has commonly been identified with the form here defined as *Girtyella turgida*, but it is a larger species besides being totally different from that one in the apical portion of the interior of the brachial valve; it differs externally from that species in the absence of a mesial sinus in the brachial valve and in having the beak of the pedicle valve a little less incurved. The species resembles *Dielasma sinuata* externally, but it is much smaller and the different mode of attachment of the crural plates in the apex of the brachial valve is a character of generic value.

Horizon.—Salem limestone.

Cranæna (?) allei (Winchell)

Plate XXXIV, Fig. 51

1865. *Centronella Allei* Winchell, Proc. Acad. Nat. Sci. Phil., p. 123.
1901. *Dielasma allei* Weller, Trans. St. Louis Acad. Sci., vol. 11, pp. 162 and 189, pl. 14, fig. 10.

Description.—Shell small, subovate or ovate-subpentagonal in outline, the anterior margin rounded, the greatest width near the mid-length. The dimensions of a pedicle valve are: length 10.5 mm., width 9 mm., convexity 2.5 mm. The dimensions of a brachial valve are: length 9 mm., width 8.8 mm., convexity 2 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface moderately convex in the umbonal region and rather abruptly

inflected towards the cardinal extremities, gently convex to the antero-lateral and anterior margins; mesial sinus obsolete; the beak a little flattened, incurved, pierced by a rather large foramen which encroaches upon the umbonal region. Internally the dental lamellæ are well developed and of moderate length.

Brachial valve subequally convex with the pedicle, its greatest convexity near or posterior to the middle, the surface curving more abruptly to the postero-lateral margins and gently to the antero-lateral and anterior margins; neither mesial fold nor sinus present; the beak pointed, incurved beneath that of the opposite valve. Internal characters not determined.

Remarks.—In the preparation of the original description of this species Winchell probably had two or more different forms in hand. The type specimens are said to have come from the upper "Yellow sandstone" and the "Oolite bed" of the Kinderhook at Burlington, Iowa, and it is said also to occur at Hamburg, Illinois, and Talmadge, Ohio. In the original definition a specimen from the upper yellow sandstone was used as the basis for the description of the pedicle valve, and specimens from the oolite were used for the description of the brachial valve and the shell structure. It is probable that these specimens belong to two different forms, and the form from the yellow sandstone will here be considered as the type of the species. The true generic characters of this yellow sandstone species has not been determined, and cannot be in the condition of preservation in which specimens have been found. It can be clearly seen, however, that they do not possess a median septum in the brachial valve and therefore cannot belong to the genus *Girtyella*, neither do they have the crural lamellæ resting upon the inner surface of the valve as in *Dielasma*, and the species can therefore be excluded from that genus. The specimens from the Hamburg, Illinois, locality are certainly examples of the shell which has here been defined as *Hamburgia typa*, and while the yellow sandstone specimens are certainly specifically different from these Hamburg shells, it is still possible that they belong to the same genus. The species is referred to *Cranæna*, however, because on the whole its members seem more closely to resemble other species of that genus than anything else.

Horizon.—Kinderhook.

Genus *DIELASMOIDES* Weller

Description.—Shell terebratuliform. Pedicle valve bisinuate towards the front in the genotype, the two depressions separated by a low, broadly rounded mesial elevation; the dental lamellæ well developed internally; the foramen large, oblique, encroaching wholly upon the umbonal region. Brachial valve with a slight mesial flattening or depression anteriorly

in the genotype; internally the socket plates are supported at their inner margins by a pair of lamellæ which pass obliquely towards the floor of the valve to which they are joined near the median line, between these lamellæ, the outer walls of the valve, and the socket plates, are a pair of cavities narrowly triangular in cross-section, which expand anteriorly and open out into the general cavity of the valve; the crura originate from the anterior extension of the inner walls of the socket plates.

FIG. 27.—A series of seven cross-sections of the rostral portion of the shell of *Dielasmoides bisinuata* (× 2½), showing the dental lamellæ of the pedicle valve, and the lamellæ supporting the hinge-plate in the brachial valve.

Remarks.—In the presence of the triangular cavities in the apical portion of the brachial valve this genus resembles *Dielasma*, but in this case the outer bounding walls of the cavities are the socket plates rather than the basal portions of the special crural lamellæ, and the crura are anterior extensions from the inner walls of the sockets instead of arising as separate crural lamellæ originating at the apex of the valve. The special, transverse, musele-bearing plate is also absent in this genus. The genus is perhaps to be compared with *Girtyella* as the form to which it is most closely allied. As in *Girtyella* the crura originate from the inner walls of the sockets, but the hinge-plate supported by a median septum is wanting. The supporting lamellæ of the socket-plates, however, may be considered as a hinge-plate similar to that of *Girtyella*, which has become so deeply concave that it rests upon and is coalescent with the outer wall of the valve at and on either side of the median line. This arrangement of the lamellæ in the rostral portion of the brachial valve is considered as the essential generic character of the group; whether the bisinuate configuration of the pedicle valve is also of generic value can not be determined from the single species of the genus so far recognized.

DIELASMOIDES BISINUATA Weller

Plate XXXI, Figs. 19-24

1911. *Dielasmoides bisinuata* Weller, Jour. Geol., vol. 19, p. 443, figs. 3a-g

Description.—Shell below medium size, ovate in outline, the greatest width anterior to the mid-length, the anterior margin rounded. The dimensions of two nearly complete specimens are: length of pedicle valve 20.5 mm. and 16.3 mm., length of brachial valve 18.9 mm. and 14.9 mm., greatest width 14.3 mm. and 12.8 mm., thickness 8.6 mm. and 8 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, convexly curved from front to beak with the curvature progressively greater posteriorly, the surface only gently convex transversely in the posterior two-thirds of the valve, except towards the postero-lateral margins where it is abruptly curved towards the opposite valve and becomes inflected towards the cardinal extremities; towards the front of the valve, about one-third of its length from the anterior margin, two shallow, broadly rounded, longitudinal depressions or sinuses originate, which lie symmetrically on each side of a low, broadly rounded mesial fold which, however, does not rise above the general surface of the valve outside the longitudinal sinuses; the beak strongly incurved so that the delthyrium is entirely hidden by the contact with the opposite valve, the foramen large and encroaching wholly upon the umbonal portion of the valve. Internally the dental plates are well developed and extend anteriorly from the beak for about one-sixth or one-fifth the length of the valve.

Brachial valve subequally convex with the pedicle, the greatest convexity posterior to the middle, the curvature of the surface along the median line is gently convex with the curvature more abrupt posteriorly, transversely the surface is somewhat narrowly rounded in the mesial portion and then slopes with a gently convex curvature to the lateral margins, the curvature becoming more abrupt posteriorly; mesial portion of the valve in its anterior one-fourth, depressed in a short, rather broad and shallow mesial sinus, the bounding folds on either side scarcely differentiated from the general curvature of the valve; the beak pointed and incurved beneath that of the opposite valve. Internally, the socket plates lie in nearly the plane of the valve posteriorly, and are supported at their inner margins by a pair of lamellæ which extend obliquely to the floor of the valve to which they are joined on either side of the median line, the crural bases being an anterior extension of the inner edges of the socket plates; median septum absent.

Remarks.—This species is peculiar among our loop-bearing shells in having the bisinuate configuration of the pedicle valve towards the front, and the short median sinus in the brachial valve. This configuration is sometimes obscure, especially in smaller or immature shells, but in full grown specimens it is probably always present in some degree, although more pronounced in some individuals than in others. In its general form, aside from its bisinuate configuration, the species most closely resembles some species of *Diclasma*, especially such a species as *D. subspatulata*, although the greatest width of the shell is not so far forward as in that species.

Locality.—Patrick's Quarry, Middle Fabins river, Lewis Co., Mo.

Genus *DIELASMA* King

Description.—Shell terebratuliform. Pedicle valve with or without a median sinus, and with well-developed dental lamellæ internally, the foramen large and encroaching upon the umbonal portion of the valve, the beak strongly incurved. Brachial valve usually without mesial fold; internally the crural plates are separate from the dental socket plates, they diverge from the apex of the valve with an elongate attachment to the inner surface of the valve, the free portion of the brachidium is short with diverging descending lamellæ; between the crural plates for the full length of their attachment to the inner surface of the valve, is a concave, transverse plate for muscular attachment, which joins the inner surface of the crural plates a little above their bases, this plate rests against the inner surface of the valve along the median line for a portion or the whole of its length, or may be free throughout, when attached

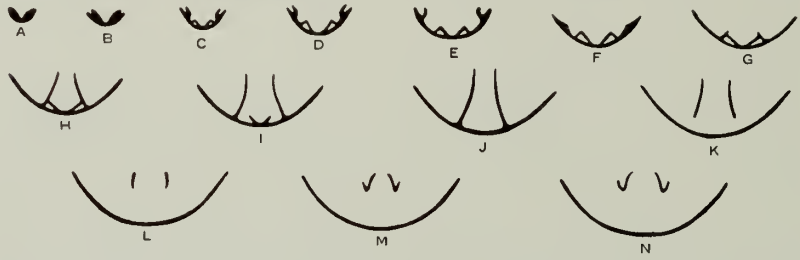

FIG. 28.—A series of fourteen cross-sections of the rostral portion of the brachial valve of *Dielasma formosum* (× 2½), showing the development of the crural lamellæ entirely independent from the hinge-plate, and the transverse, muscle-bearing plate between them.

along the median line a pair of slender cavities, triangular in cross section, converge from the general cavity of the shell towards the beak; when the transverse plate is not attached along its median line there is a single, broad and low cavity beneath the plate extending towards the apex, anteriorly this plate extends to a greater or less distance beyond the attachment of the crural plates and is pointed, rounded or emarginate in front, its surface is marked by concentric wrinkles parallel with its anterior margin which are usually discontinuous along the median line.

Remarks.—The genus *Dielasma* was established by King with *Terebratula elongatus* Schl. as genotype, and although he defined the genus primarily upon the presence of prominent dental lamellæ in the pedicle valve and on the form of the loop, his illustrations of the internal casts of the species under the name *Epithyris elongata*[1] show that the crural plates are separate from the socket walls, one of the most essential features of *Dielasma* as here defined. Davidson[2] gives illustrations of the same species which

[1] Mon. Permian Foss. Eng., pl. 6, figs. 37, 41. (1850.)
[2] Brit. Foss. Brach., vol. 2, Permian, pl. 1, figs. 18, 20. (1857.)

exhibit all the essential generic characters of *Dielasma* most perfectly. The interpretation of the genus by Hall and Clarke[1] is identical with that here given, but those authors included certain species in the genus without sufficient investigation of their internal characters, which are really fundamentally different; it has in fact been the usual custom among American workers, since the publication of Hall and Clarke's work, to refer all Mississippian terebratuloid shells to the genus *Dielasma*.

In specimens preserved in the condition of internal casts the generic characters of *Dielasma* are always very obvious, the position of crural lamellæ, separate from the socket plates being indicated by a pair of slits diverging from the beak of the brachial valve; when the transverse muscle-bearing plate is attached along its mesial line a second pair of diverging slits are present between those formed by the crural lamellæ and the finger-like casts of the slender cavities beneath the transverse plate are clearly shown, whether they are actually present or broken off. In specimens having the shell preserved the shell substance is frequently translucent enough to show the position of the internal lamellæ as dark lines, in which case the genus can be recognized at once, and when the shell is opaque it is usually easy to determine the generic characters by the judicious use of a needle, without injuring the specimen as to its external form and characters upon which the various species are differentiated.

Dielasma chouteauensis n. sp.

Plate XXXII, Figs. 1-17

1895. *Dielasma formosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, fig. 24 (not figs 12-23, 25-26).

Description.—Shell of medium size or larger, subovate or obscurely subpentagonal in outline, the greatest width near the middle, the anterior margin rounded. The dimensions of a nearly complete example are: length of pedicle valve 32 mm., length of brachial valve 29.3 mm., greatest width 23.2 mm., thickness ±15 mm.

Pedicle valve most convex posterior to the middle, arched from beak to front along the median line with the curvature becoming progressively greater posteriorly, the surface convexly curved from the median line towards the postero-lateral margins for a little more than half way to the margins where it is rather abruptly inflected to a slight degree, along a narrowly rounded, arched ridge which originates at the side of the beak and terminates at the lateral margin posterior to the middle of the valve, beyond this arched ridge the inflected surface is usually gently concave, to the lateral, antero-lateral and anterior margins the surface is gently convex; the mesial portion of the valve is usually slightly flattened be-

[1] Pal. N. Y., vol. 8, pt. 2, pp. 293-294. (1894.)

tween ill-defined lines, but is not depressed in a median sinus; the beak prominent, pointed and incurved, pierced by a large, subovate foramen which encroaches upon the umbonal region, only coming in contact with the delthyrium at its apex; the delthyrium almost totally hidden by the incurvature of the beak. Internally the dental lamellæ are well developed

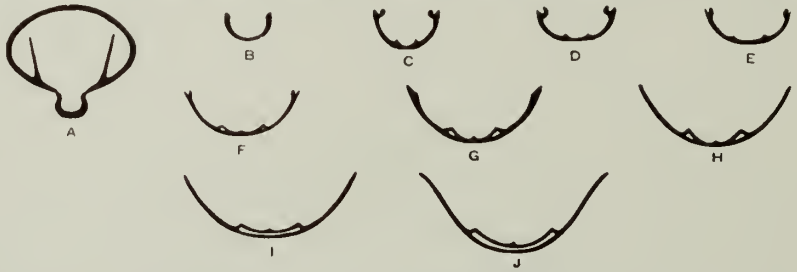

FIG. 29.—A series of ten cross-sections of the rostral portion of the shell of *Diclasma chouteauensis* (× 2½), showing the dental lamellæ of the pedicle valve (A), and the development of the independent crural lamellæ of the brachial valve, with a transverse, muscle-bearing plate which becomes entirely free from the floor of the valve anteriorly.

and reach nearly one-fourth the length of the valve from the beak; the muscular scars obscure, bounded laterally by a pair of shallow, narrow, rounded furrows in the inner surface of the valve which diverge from the beak between the dental lamellæ and extend about two-thirds the length of the valve from the beak.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, arched from beak to front with the greater curvature posteriorly, the surface curving abruptly to the postero-lateral margins and gently to the anterior and antero-lateral margins; the median portion of the valve not differentiated as a fold or sinus and scarcely even flattened; the beak acutely pointed, incurved beneath that of the opposite valve. Internally the socket plates are distinct from the crural plates; the crural plates originate as a pair of slight angular ridges diverging from the apex upon the inner surface of the valve; between these ridges is a concave platform-like area for muscular attachment which is at first wholly confluent with the inner surface of the valve, anteriorly it becomes elevated a little above the floor of the valve laterally, leaving a narrow, triangular, pocket-like cavity on each side, still further towards the front this platform is elevated above the inner surface of the valve through its entire width, leaving a broad, shallow cavity between its under surface and the inner surface of the valve, the anterior extremity reaching one-third or more of the length of the valve from the apex.

Surface of both valves, at least in well preserved exfoliated examples, marked towards the lateral and anterior margins by exceedingly faint,

depressed, radiating costæ, about three of which occupy the space of one millimeter; the concentric lines of growth are more or less obscure in smaller individuals, becoming somewhat stronger and more crowded towards the outer margin of large individuals. Shell structure finely and closely punctate.

Remarks.—This species is rather common in the Chouteau limestone of central Missouri. Hall and Clarke illustrated a large, typical example of the species as *Dielasma formosa*, but it may be easily distinguished from that species by the more depressed convex valves which are much more regularly convex transversely. Internally the two species are also distinct, though both possess the essential characters of *Dielasma;* in *D. chouteauensis* the muscular platform of the brachial valve becomes elevated free from the inner surface of the valve anteriorly, while in *D. formosa* the median contact is retained throughout. The fine, radiating costæ have been observed on only a few examples; it is possible that they were uniformly present upon the living shells, but have usually been obliterated in the fossils by exfoliation since all the known examples occur in that condition.

Horizon.—Chouteau limestone.

Dielasma fernglenensis Weller

Plate XXXIII, Figs. 4-5

1909. *Dielasma fernglenensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 318, pl. 14, fig. 7.

Description.—Shell large, subovate in outline, longer than wide, the greatest width a little anterior to the middle. The dimensions of the type specimen, as nearly as can be determined, are: length of pedicle valve 55 mm., length of brachial valve 51.4 mm., width —43 mm., thickness ±25 mm.

Pedicle valve moderately convex, the curvature greatest towards the postero-lateral margins, becoming inflected towards the cardinal extremities; mesial portion of the valve not differentiated from the general curvature of the surface; beak pointed and closely incurved, pierced by a large foramen which encroaches wholly upon the umbonal portion of the valve, the deltidial plates hidden by the incurvature of the beak. Internally the dental lamellæ well developed and of moderate length.

Brachial valve probably about equally convex with the pedicle, the curvature strongest towards the postero-lateral margins, rather gentle to the antero-lateral and anterior margins; mesial portion of the valve not differentiated from the general curvature of the surface; beak pointed and incurved beneath the pseudodeltidium of the opposite valve. Internally the crural lamellæ diverge from the beak and are separate from the socket plates, being joined transversely by a concave, muscle-bearing plate as in

all members of the genus *Dielasma,* but the details of these structures cannot be determined in the type specimen.

Surface of the valves apparently nearly smooth except towards the outer margin where there are several concentric lines of growth varying in strength. The shell structure is finely and closely punctate.

Remarks.—This species resembles *D. choutcauensis,* but it is proportionally broader, and has the transverse, muscle-bearing plate, between the bases of the crural lamellæ, attached to the floor of the valve through the whole, or nearly the whole, of its length.

Horizon.—Fern Glen formation.

Dielasma cseolensis n. sp.

Plate XXXIII, Figs. 1-3

Description.—Shell large, elongate-subovate in outline, the anterior margin rounded, the greatest width near the mid-length. The dimensions of a very complete but slightly distorted example, the holotype, are: length of pedicle valve 52 mm., length of brachial valve 48 mm., greatest width 32.4 mm., thickness 22.8 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface arcuate from beak to front with the curvature increasingly convex posteriorly, curving rather abruptly towards the postero-lateral margins, becoming incurved to the cardinal extremities, the curvature to the antero-lateral and anterior margins more gentle; mesial sinus obsolete but the mesial portion of the valve is obscurely flattened; the beak prominent, pointed, strongly incurved, the deltidial plates nearly hidden by the incurvature, the foramen very large, elongate-ovate, encroaching wholly upon the umbo. Internally the dental plates are strongly developed and elongate, reaching anteriorly from the beak nearly one-fourth the length of the valve.

Brachial valve a little less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving more abruptly to the postero-lateral margins and somewhat gently to the antero-lateral and anterior margins; mesial portion of the valve obscurely flattened but not differentiated from the general convexity; the beak pointed and incurved beneath that of the opposite valve. Internally the crural lamellæ are separate from the socket plates and diverge anteriorly from the beak, extending about one-fifth the length of the valve; entire brachidium not observed.

Surface of both valves marked only by concentric lines of growth which are obscure posteriorly, becoming stronger and wrinkle-like towards the front. Shell substance finely punctate.

Remarks.—This species is one of the largest in our faunas and resembles some European specimens which have been identified as *Terebratula hastata,*

it differs from the original illustration of that species, however, in the absence of a mesial sinus in each valve. It more closely resembles *D. choutcauensis* or *D. fernglenensis* than any of the other species here described, but it is a proportionally narrower shell with more convex valves

Horizon.—Lower Burlington limestone.

Dielasma burlingtonensis (White)

Plate XXXI, Figs. 45-49

1860. *Terebratula burlingtonensis* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 228.

Description.—Shell below medium size, elongate-ovate in outline, the greatest width near the mid-length, the anterior margin rather narrowly rounded. The dimensions of a nearly perfect but slightly distorted specimen, a cotype, are: length of pedicle valve 16.' mm., length of brachial valve 15.1 mm., greatest width 10.6 mm., thickness 7.5 mm. A large pedicle valve with a width of 13.4 mm. has the anterior portion too incomplete to allow the accurate measurement of the length which was probably about 20 mm.

Pedicle valve with its greatest depth posterior to the middle, arched from beak to front with the convexity somewhat greater posteriorly, the surface curving abruptly from the median line to the postero-lateral margins, becoming a little inflected to the cardinal extremities, curving more gently to the antero-lateral and anterior margins; mesial sinus obsolete; beak prominent, only slightly incurved, truncated by the very large, subovate foramen which encroaches wholly upon the umbonal region of the valve, its margin fixing a plane which is either at a right angle to the plane of the valve or even slopes anteriorly from the posterior to the anterior margins of the foramen; the delthyrium large, its greater portion filled by the beak of the opposite valve, its apex closed by a pair of deltidial plates. Internally the foramen is bordered by a distinct pedicle collar extending towards the interior of the valve; the dental lamellæ are rather short and widely separated.

Brachial valve a little less convex than the pedicle, its greatest depth posterior to the middle, the surface curving somewhat abruptly to the postero-lateral margins and more gently to the antero-lateral and anterior margins; mesial portion of the valve without fold or sinus; the beak pointed and incurved beneath the margin of the deltidial plates of the opposite valve. Internally the situation of the crural plates separate from the socket plates, with the transverse, muscle-bearing plate joining the inner surface of the valve medially, may be recognized from the position of dark lines showing upon the external surface.

Surface of both valves nearly smooth, marked only by very indistinct, concentric lines of growth.

Remarks.—This species is a rare one and has not been available in sufficient numbers to make it possible to grind any examples for the purpose of determining its internal characters. The interior of the pedicle valve, however, is perfectly shown in one of the cotypes, and the essential features of the genus *Diclasma* can be recognized from the external surface of the brachial valve of another cotype, the position of the crural lamellæ and the transverse muscle plate being clearly indicated by dark lines. In size, and in the entire absence of fold and sinus, the species resembles *D. formosa*, but it is a somewhat more slender shell with less convex valves and with the beak of the pedicle valve less incurved; the species is especially characterized, however, by the large size of the foramen which is directed straight posteriorly or even obliquely away from the brachial valve, while in *D. formosa* the foramen is directed obliquely posterobrachially. The concentric growth lines of the shell are also much less conspicuous in this species than in *D. formosa*.

Horizon.—Burlington limestone.

Dielasma sinuata n. sp.

Plate XXXI, Figs. 28-34

1883. *Lingula crawfordsvillensis* Gurley, New Carb. Foss., Bull. No. 1, p. 2.
1895. *Diclasma formosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 16-17 (not figs. 12-15, 18-26).
1906. *Diclasma turgidum* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1309, pl. 19, figs. 5-5a (not pl 22, figs. 53-58).
1906. *Diclasma gorbyi* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1310, pl. 20, fig. 5 (not *Terebratula gorbyi* Miller).

Description.—Shell of medium size, subovate or ovate-subpentagonal in outline, longer than wide, the greatest width near the mid-length of the shell, the anterior margin rounded, nearly straight or a little emarginate. The dimensions of an internal cast, somewhat restored, are: length of pedicle valve 29.2 mm., length of brachial valve 23.6 mm., greatest width 18.7 mm., thickness 20.9 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region projecting conspicuously beyond the beak of the opposite valve in full grown specimens, the surface arched from beak to front with the curvature becoming progressively more convex posteriorly, the lateral slopes curving abruptly and steeply from the median portion of the valve to the lateral margins, becoming somewhat inflected towards the cardinal extremities, the lateral margins joining those of the opposite valve in a broadly obtuse angle; mesial sinus originating near the middle of the valve, rather narrow, with subparallel sides, rounded or a little flattened in the bottom, its lateral borders rounding into the lateral slopes of the valve, of moderate depth or becoming strongly de-

pressed towards the front, sometimes produced anteriorly in a short, rounded, lingual extension; beak prominent, strongly incurved, pierced by a large foramen which encroaches wholly upon the umbonal region, being in contact with the delthyrium only at its apex; delthyrium broadly triangular, hidden by the incurvature of the beak. Internally the dental lamellæ are well developed and of moderate length, the muscular scars obscure or obsolete.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the surface arched from beak to front with the curvature becoming continuously more convex towards the beak, the lateral slopes convex, curving abruptly from the median line to the lateral margins; mesial portion of the valve not differentiated as a fold to correspond with the sinus of the opposite valve, but the anterior margin commonly exhibits a rounded sinuosity to correspond with the short lingual extension of the opposite valve; beak pointed and incurved beneath that of the opposite valve. Internally the crural plates are separated from the socket plates and diverge anteriorly, at the beak they are low, angular ridges but become thin, rather highly elevated lamellæ anteriorly, they are joined transversely by a concave plate bearing the muscular scars which is attached to the inner surface of the valve along its median line, leaving a pair of triangular, finger-like cavities converging towards the beak, which are surrounded by the inner surfaces of the base of the crural plates, the muscle plate and the inner surface of the valve; anteriorly the muscle-bearing plate extends considerably beyond the termination of the attached portion of the crural lamellæ; the muscle scars are commonly rather strongly impressed upon the surface of the concave muscle plate.

Surface of both valves smooth externally except for the presence of concentric lines of growth which vary greatly in strength upon different individuals; upon some internal casts exceedingly faint radiating costæ are sometimes distinguishable towards the lateral and anterior margins.

Remarks.—This species has been identified sometimes as *Girtyella turgida*, but besides being a much larger species and lacking the mesial depression of the brachial valve towards the front, the internal structure of the rostral portion of the brachial valve is totally different and the two species cannot even be included in the same genus. The brachial valve of the species has been identified sometimes as *D. formosa*, but it differs from the corresponding valve of that species in being somewhat flatter medially, in having a less pointed anterior outline, and in having the mesial sinuosity in the anterior margin for the accommodation of the anterior extremity of the sinus of the opposite valve.

Horizon.—Keokuk limestone, Salem limestone.

Dielasma inflata n. sp.

Plate XXXII, Figs. 18-28

1894. *Dielasma turgida* Hall and Clarke, Int. to Study of Brach., pl. 53, fig. 12 (not figs. 10-11).

1895. *Dielasma turgida* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, fig. 4 (not figs. 1-3, 5-8).

Description.—Shell below medium size, longer than wide, subovate or subangularly subpentagonal in outline, the greatest width near or anterior to the middle, the anterior margin emarginate or slightly convex, the valves gibbous, often geniculate near the middle, the thickness of the shell sometimes exceeding the width. The dimensions of two complete examples are: length of pedicle valve 13.5 mm. and 16.8 mm., length of brachial valve 11.5 mm., and 14.6 mm., greatest width 8.2 mm. and 12 mm., thickness 9.8 mm. and 12.2 mm.

Pedicle valve gibbous, the curvature abruptly changed in mature examples near the mid-length of the valve, where it is bent in a subgeniculate manner, the curvature to the postero-lateral margins is abrupt, the surface becoming inflected to the cardinal extremities, towards the antero-lateral and anterior margins the curvature is rather gently convex to the line of geniculation, beyond which the surface drops abruptly to the margins; mesial sinus originating at the line of geniculation, usually flat in the bottom, slightly or strongly depressed towards the margin, the median, flattened portion a little produced anteriorly in a short, rounded, lingual extension; beak prominent, strongly incurved, its apex nearly or quite in contact with the umbo of the opposite valve, pierced by a large, subovate foramen which encroaches wholly upon the umbonal region of the valve, the delthyrium hidden by the incurvature of the beak, in contact with the foramen only at its apex, entirely filled by the pseudodeltidium. Internally the dental lamellæ are well developed and reach anteriorly from the beak nearly one-fourth the total length of the valve.

Brachial valve a little less convex than the pedicle, the surface geniculate as in the opposite valve, curving rather abruptly to the postero-lateral margins and more gently to the antero-lateral and anterior margins up to the line of geniculation beyond which it drops abruptly to the margin; in front of the line of geniculation the median portion of the valve is marked by three longitudinal folds separated by subangular or rounded furrows, the median one of the three folds is opposite the slight lingual extension from the anterior margin of the sinus of the pedicle valve, it may be somewhat elevated above the two lateral folds, even with them or depressed between them; the beak pointed, incurved beneath that of the opposite valve. Internally the socket plates are distinct from the crural plates, the latter are attached to the inner surface of the valve for more than one-fourth its length anteriorly from the beak, a little less

than half way between the median line of the valve and the lateral margins, the crural plates are joined transversely by a concave plate bearing the muscle scars, which is in contact with the inner surface of the valve medially, leaving a pair of finger-like, triangular cavities converging and diminishing in size towards the beak, each bounded by the base of a crural plate, the muscle plate and the inner surface of the valve.

Surface of both valves smooth posterior to the line of geniculation, but anterior to this line it is marked by more or less conspicuous concentric lines of growth. The shell structure finely punctate.

Remarks.—This species is one of those which has commonly been referred to *Girtyella turgida*, but besides possessing characters of the rostral portion of the brachial valve which are generically different from that species, the external configuration of the shell is very different. The shell attains a much larger size than *G. turgida*, and differs from it in the geniculate habit of growth of the shell, and also in the much more conspicuous triplication of the brachial valve towards the anterior margin. The more conspicuous variations observed in the species are the proportional width of the shell and the depth of the mesial sinus. In some examples the width and thickness of the shell is nearly equal, while in others the thickness exceeds the width to a notable degree. The internal characters of the rostral portion of the brachial valve have been determined only from the markings of the septa as seen upon the exfoliated external surface, but these clearly indicate the genus *Dielasma*.

Horizon.—Salem limestone.

Dielasma formosum (Hall)

Plate XXXIII, Figs. 12-17

1856. *Terebratula formosa* Hall, Trans. Albany Inst., vol. 4, p. 6.
1882. *Terebratula formosa* White, 11th Ann. Rep. Geol. Surv. Ind., p. 361, pl. 39, figs. 6-8.
1882. *Terebratula formosa* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 55, pl. 6, figs. 59-64.
1883. *Terebratula formosa* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 337, pl. 29, figs. 59-64.
1894. *Dielasma formosa* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 53, figs. 15-17 (not 18-19).
1895. *Dielasma formosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 18-23, 25-26 (not figs. 12-17, 24).
1895. *Dielasma obovata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 38-40.
1897. *Dielasma obovata* Hall and Clarke, 14th Ann. Rep. N. Y. State Geol., p. 372, pl. 14, figs. 12-14.
1906. *Dielasma formosum* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1310, pl. 22, figs. 59-64.
1911. *Dielasma formosa* Weller, Jour. Geol., vol. 19, p. 440, figs. 1a-n.

Description.—Shell usually below medium size, elongate-ovate in outline, the greatest width near or anterior to the middle, the anterior margin rounded. The dimensions of a very perfect specimen are: length of pedicle valve 15.4 mm., length of brachial valve 13.8 mm., maximum width 10.2 mm., thickness 9 mm.

Pedicle valve most convex posterior to the middle, arched along the median line from beak to front with a convexity progressively increasing posteriorly, the surface curving abruptly from the median line to the postero-lateral margins and becoming inflected to the cardinal extremities, curving more gently to the antero-lateral margins; mesial sinus obsolete; beak prominent, incurved, pierced by a large, subcircular or subovate foramen which encroaches wholly upon the umbonal region of the valve, in contact with the delthyrium only at its apex; delthyrium broadly triangular, entirely closed, except around the border, by the beak of the opposite valve and the deltidial plates which are invisible externally, because of the incurvature of the beak. Internally the dental lamellæ are well developed and extend anteriorly from the beak for nearly one-fourth the total length of the valve.

Brachial valve a little less convex than the pedicle, the greatest convexity near or a little posterior to the middle, arched from beak to front along the median line with the curvature a little greater posteriorly, the surface curving rather abruptly from the median line to the postero-lateral margins, becoming more gently curved anteriorly; mesial portion of the valve not differentiated as fold or sinus; the beak acutely pointed, incurved beneath that of the opposite valve. Internally the socket plates are separate from the crural plates and are not connected by a hinge-plate; the crural plates originate near the apex of the valve about half way between the median line and the lateral margins, gradually approaching, relatively, the median line anteriorly, they are low and strongly inclined inward posteriorly, abruptly becoming very greatly increased in height anteriorly and becoming more erect, posteriorly they are joined by a concave, platform-like plate bearing the muscular scars, which is medially in contact with the inner surface of the valve leaving a pair of triangular, finger-like cavities diverging from the beak, which are surrounded by the inner surfaces of the crural plates, the muscle plate and the floor of the valve; the brachidium is short, its anterior extremity falling short of the middle of the valve.

Surface of both valves nearly smooth or marked only by concentric lines of growth which are sometimes strongly developed and rather closely crowded. Shell structure finely punctate.

Remarks.—Various forms have been referred to this species in the literature. In volume eight of the New York Paleontology no less than four distinct species belonging to two different genera are illustrated under

the name *D. formosa*, and most of the loop bearing shells of the Mississippian faunas commonly have been referred, in recent years, either to this species or to *Girtyella turgida*. The species is a well-defined one, characterized by the ovate outline of the shell, rounded in front, with neither fold or sinus in either valve. The shell described by Hall and Clarke as *D. obovata* and said to be from the Pennsylvanian is evidently a large example of this species. The original label with the type specimen is marked "Carboniferous Limestone, Kentueky," with no suggestion that it came from the Pennsylvanian. Furthermore, the lithologic character of the specimen is identieal with speeimens from the Salem limestone of southern Indiana or Kentueky, the typieal horizon for *Dielasma formosa*.

Horizon.—Salem limestone.

Dielasma illinoisensis n. sp.

Plate XXXIII, Figs. 18-20

Description.—Shell below medium size, elongate subovate in outline, the greatest width near the mid-length, the anterior margin rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 21 mm., length of brachial valve 18.8 mm., greatest width 12.7 mm., thickness 10 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface arcuate from beak to front along the median line with the curvature increasingly convex posteriorly, the convexity at first moderate from the median line towards the postero-lateral margins, curving more abruptly as it approaches the margin and becoming inflected to the cardinal extremities, the curvature more gentle towards the antero-lateral margins; mesial sinus of moderate width and depth, rounded in the bottom, originating near or a little posterior to the middle of the valve; the beak prominent and elosely ineurved, the foramen large, subcircular or subovate in outline, eneroaching wholly upon the umbonal portion of the valve, the deltidial plates hidden by the incurvature of the beak. Internally the dental lamellæ are well developed and of moderate length.

Fig. 30.—A series of seven cross-sections of the rostral portion of the shell of *Dielasma illinoisensis* (× 2½), showing the dental lamellæ of the pedicle valve, and the crural lamellæ developed independently from the socket plates.

The brachial valve less convex than the pediele, gently eonvex longitudinally from beak to front, the curvature usually a little greater near

the beak, sometimes nearly straight towards the anterior margin, transversely it is strongly convex with the curvature more abrupt towards the postero-lateral margins; mesial portion of the valve not differentiated from the general curvature of the surface, or elevated in a slight mesial fold near the anterior margin; beak sharply pointed, incurved beneath the pseudodeltidium of the opposite valve. Internally the crural plates are distinct from the socket plates and diverge anteriorly from the beak, being attached to the inner surface of the valve for nearly one-fourth the length of the valve; the concave muscle bearing plate joins the inner surface of the valve along its median line and extends anteriorly about two-fifths the length of the valve.

Surface of both valves nearly smooth, marked only by rather inconspicuous lines of growth. The shell structure finely punctate.

Remarks.—This species differs from *D. sinuata* in its smaller size, less strongly convex valves, especially the less longitudinal convexity of the brachial valve, and in its more slender form.

Horizon.—Chester group, Paint Creek formation.

Dielasma shumardanum (Miller)

Plate XXXI, Figs. 25-27

1863. *Terebratula arcuata* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 83. (Not *T. arcuata* Roemer, 1840.)
1883. *Terebratula shumardana* Miller, Am. Pal. Foss., 2nd ed., p. 299.

Description.—Shell of medium size or a little larger, elongate subovate in outline, with the greatest width well towards the anterior, the anterior margin rounded, the postero-lateral margins gently convex. The dimensions of a nearly perfect specimen are: length of pedicle valve 29 mm., length of brachial valve 26.5 mm., greatest width 19.6 mm., thickness 14.5 mm.

Pedicle valve strongly arcuate from beak to front, the curvature increasingly convex towards the beak, the greatest convexity posterior to the middle, the surface broadly flattened, gently convex transversely in the posterior portion of the valve to near the postero-lateral margins where it is rather abruptly curved towards the opposite valve and inflected towards the cardinal extremities, anteriorly the surface is gently convex to the lateral margins; mesial sinus narrow and shallow, originating at or near the beak, not sharply defined along its lateral margins; the beak truncated, incurved, the foramen large, subovate, encroaching wholly upon the umbonal portion of the valve, the deltidial plates hidden by the incurvature of the beak. Internally the dental lamellæ are well developed and of moderate length.

Brachial valve gently convex from beak to front along the median line with the highest point near the middle, strongly convex transversely

with the curvature more abrupt to the postero-lateral margins; the mesial portion of the valve either not differentiated from the general convexity, or elevated in a slight, obscure, mesial fold near the front; beak sharply pointed, incurved beneath the deltidial plates of the opposite valve. Internally the socket plates and crural plates are distinct, the lines of attachment of the crural plates to the inner surface of the valve diverge from the beak and extend anteriorly about one-fourth the length of the valve; the concave muscle bearing plate between the crural lamellæ is emarginate in front and extends anteriorly from the beak about two-fifths the total length of the valve, it is marked by fine concentric wrinkles parallel with the anterior margin of the plate and discontinuous along a narrow median line.

Surface of both valves nearly smooth, marked only by more or less obscure concentric lines of growth. Shell structure finely punctate.

Remarks.—This species has not been commonly recognized since its original definition by Swallow as *Terebratula arcuata*, and it seems to be a rather rare species. In its arcuate form the shell resembles the Pennsylvanian species *D. bovidens*, and it has sometimes been so identified, but it is somewhat more elongate than that species, less strongly arcuate, and the median sinus of the pedicle valve is much narrower.

Horizon.—Chester Group, Okaw formation.

Dielasma arkansanum n. sp.

Plate XXXI, Figs. 35-44

Description.—Shell about medium size, subovate in outline, longer than wide, the greatest width a little in front of the middle. The dimensions of a nearly complete specimen are: length of pedicle valve 30.5 mm., length of brachial valve 28.2 mm., greatest width 21 mm., thickness 14 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface arched longitudinally from beak to front with the curvature becoming progressively more convex posteriorly, from the umbonal region the surface is moderately convex to near the postero-lateral margins, where it is more abruptly curved and inflected towards the cardinal extremities, towards the antero-lateral and anterior margins the convexity is more gentle; mesial sinus narrow and very shallow, ill-defined laterally, originating at or near the mid-length of the valve, frequently nearly or quite obsolete; beak strongly incurved, pierced by a large, oblique, subovate foramen which encroaches wholly upon the umbonal portion of the valve, the deltidial plates hidden by the incurvature of the beak. Internally the dental plates are well developed and of moderate length.

Brachial valve less convex than the pedicle, its greatest convexity near or posterior to the middle, the surface curving rather abruptly from the median line to the postero-lateral margins and more gently to the antero-lateral and anterior margins; mesial portion of the valve not differentiated from the general convexity of the valve; the beak acutely pointed and incurved beneath the pseudodeltidium of the opposite valve. Internally the socket plates and crural plates are distinct, the attachment of the crural plates to the inner surface of the valve diverging from the apex and extending anteriorly for about one-fourth the length of the valve; the concave muscle bearing plate lying between the crural plates is elongate, rounded in front, and extends anteriorly about two-fifths the length of the valve; it is marked by strong concentric wrinkles parallel with the anterior margin which are discontinuous along a narrow median line.

Surface of both valves smooth or nearly smooth, marked only by generally obscure, concentric lines of growth. Shell structure finely and closely punctate.

Remarks.—In general form this species resembles *D. formosa,* but it is proportionally a broader and thinner shell with the greatest width situated more anteriorly, it also usually differs from that species in having a slight median sinus in the pedicle valve which is absent in *D. formosa.* The form of the shell perhaps more closely resembles *D. chouteauensis,* but that species lacks the median sinus of the pedicle valve and does not have its greatest width anterior to the middle.

Locality.—Washington County, Arkansas: Webb City, Missouri (Carterville formation?).

Dielasma subspatulatum n. sp.

Plate XXXIII, Figs. 6-11

Description.—Shell below medium size, elongate-subovate in outline, the width much greater than the thickness, the greatest width towards the front of the shell, the postero-lateral margins elongate and gently convex. The dimensions of a nearly complete specimen are: length of pedicle valve 19 mm., length of brachial valve 17.5 mm., greatest width 14.1 mm., thickness 8.2 mm.

Pedicle valve moderately convex, the greatest convexity near or posterior to the middle, arched from beak to front along the median line with the curvature a little more convex posteriorly, the surface gently convex transversely, but as it approaches the postero-lateral margins it is abruptly curved towards the opposite valve and becomes inflected towards the cardinal extremities; the mesial sinus obsolete; the beak incurved, perforated by a large foramen which encroaches upon the umbonal portion of the valve. Internally the dental plates are well developed and are of moderate length.

Brachial valve a little less convex than the pedicle, the greatest convexity posterior to the middle, along the median line from the beak to the front the surface is gently convex with the curvature a little greater posteriorly, from the middle of the valve to the front the surface is sometimes almost straight, transversely it is gently depressed convex towards the front but becomes more convex posteriorly because of the decreasing width of the valve; mesial portion of the valve somewhat broadly flattened with no fold or sinus; the beak pointed, incurved beneath that of the opposite valve. Internally the crural plates are entirely separate from the socket plates, they diverge from the apex of the valve and rise from its inner surface, the attachment extending from the beak for nearly one-fourth the length of the valve; between the crural plates the concave muscle-bearing plate extends anteriorly in the median line of the valve some distance beyond the attachment of the crural plates and terminates in a point.

Surface of both valves nearly smooth or marked by obscure concentric lines of growth. Shell structure finely punctate.

Remarks.—This species is especially characterized by the broad, transversely flattened pedicle valve, the absence of mesial fold or sinus in both valves, the gentle longitudinal convexity of the brachial valve, and the anterior position of the greatest width of the shell. It is somewhat similar to *D. bovidens* of the Pennsylvanian faunas but entirely lacks the sinus of the pedicle valve which is characteristic of that species.

Locality.—Washington County, Arkansas.

Genus *GIRTYELLA* Weller

Description.—Shell terebratuliform, the pedicle valve sinuate, with a large, subcircular or subovate, oblique foramen which encroaches upon the umbo; the brachial valve frequently sinuate and often with a slight median fold in the bottom of the sinus. Internally the dental lamellæ are well developed in the pedicle valve. In the brachial valve the socket plates are joined by a concave hinge-plate which is imperforate at the apex and is supported by a median septum; the inner sides of the dental

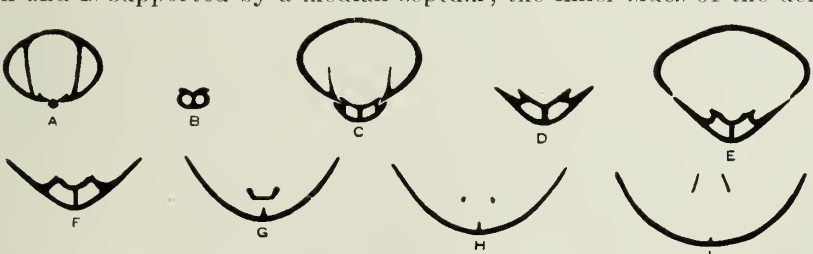

FIG. 31.—A series of nine cross-sections of the rostral portion of the shell of *Girtyella indianensis* (× 2½) from the Pella beds, showing the dental lamellæ of the pedicle valve, and the median septum, hinge-plate, and manner of formation of the crura in the brachial valve.

sockets retreat from the margins of the valve anteriorly beyond the point of articulation and become the bases of the crura which are still joined by the concave hinge-plate and are also supported by lamellae resting against the inner surface of the lateral slopes of the valve. The brachidium short, its free portion apparently being like that of *Diclasma* and not reaching to the middle of the shell.

Remarks.—Members of this genus have commonly been included in the genus *Diclasma*, but they differ fundamentally from that genus in the presence of a median septum supporting the hinge-plate of the brachial valve, and in the origin of the bases of the crura from the socket plates. In his description of the species which is selected as the genotype, Girty referred the form to the genus *Harttina* on account of the presence of a median septum in the pedicle valve, but the brachidium of *Harttina* is elongate, like that of *Cryptonella*, reaching nearly to the front of the shell, while that of *Girtyella* is short like the brachidium of *Diclasma*.

Girtyella cedarensis n. sp.

Plate XXXIV, Figs. 48-50

Description.—Shell below medium size, subovate in outline, the greatest width anterior to the middle, the anterior margin subtruncate. The dimensions of a nearly complete internal cast are: length of pedicle valve 18.5 mm., length of brachial valve 16 mm., greatest width 15.2 mm., thickness 11.9 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the postero-lateral margins and becoming somewhat inflected to the cardinal extremities, curving less abruptly to the antero-lateral and anterior margins; mesial sinus shallow, rounded in the bottom, rather broad and ill-defined laterally, originating near the middle of the valve; beak rather prominent and incurved, character of the foramen not shown in the type specimen. Internally the dental plates are rather strong and extend anteriorly from the beak between one-fifth and one-fourth the length of the valve, with only a small amount of divergence.

Brachial valve about equally convex with the pedicle, the greatest convexity near the middle, the surface curving a little more abruptly to the anterior and antero-lateral margins than posteriorly; mesial fold obsolete, but with the mesial portion of the valve obscurely flattened anterior to the middle of the valve, the beak pointed and incurved beneath that of the opposite valve. Internally a strong median septum extends anteriorly from the beak for about two-fifths the length of the valve; the characters of the hinge-plate not fully observed, but so far as determined agreeing entirely with other species of *Girtyella*.

Surface of both valves marked by concentric lines of growth which become stronger and more crowded towards the margin.

Remarks.—The holotype of this species is a nearly complete internal cast in which the dental lamellæ of the pedicle valve and the median septum of the brachial valve are clearly exhibited as slits. The species is referred to the genus *Girtyella* because of the strong median septum of the brachial valve, and, although the characters of the hinge-plate are not clearly shown in the specimen, there can be no doubt as to the correct generic reference of the species. The species is the largest member of the genus here recognized, and seems to agree more closely with *G. indianensis* than with any other, but the shell is proportionally broader and more rotund in contour than that species.

Horizon.—Northview shale and upper Chouteau limestone of the Kinderhook.

Girtyella turgida (Hall)

Plate XXXIV, Figs. 25-36

1856. *Terebratula turgida* Hall, Trans. Albany Inst., vol. 4, p. 6.
1882. *Terebratula turgida* Whitfield, Bull. Am. Mus. Nat. Hist., vol 1, p. 54., pl 6, figs. 53-58.
1883. *Terebratula turgida* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 336, pl. 29, figs. 53-58.
1893. *Dielasma turgida* Beecher and Schuchert, Proc. Biol. Soc. Wash., vol. 8, pp. 71-74, pl. 10, figs. 1-6.
1894. *Dielasma turgida* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 53, fig. 11 (not figs. 10, 12).
1895. *Dielasma turgida* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 5-6 (not figs. 1-4, 7-8).
1906. *Dielasma turgidum* Beede, 30th Ann. Rep. Geol. Surv. Ind., p 1309, pl. 22, figs. 53-58 (not pl. 19, figs. 5-5a).
1911. *Girtyella turgida* Weller, Jour. Geol., vol. 19, p. 443.

Description.—Shell small, subovate or subpentagonal in outline, the anterior margin usually emarginate but sometimes straight, the greatest width near or anterior to the middle, sometimes nearly at the front of the shell, the valves more or less gibbous. The dimensions of two individuals, the larger one an exceedingly gibbous example, are: length of pedicle valve 7.7 mm. and 8.3 mm., length of brachial valve 6.6 mm. and 6.8 mm., greatest width 6.2 mm. and 6.1 mm., thickness 5.2 mm. and 7.2 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the postero-lateral margins, becoming inflected towards the cardinal extremities, curving more gently to the antero-lateral and anterior margins; mesial sinus originating in or just in front of the umbonal region, of moderate width, its lateral boundaries rounding into the lateral slopes, rounded in the bottom and often becoming rather deep anteriorly; the beak prominent, rather blunt,

strongly incurved, coming nearly or quite in contact with the umbonal region of the opposite valve, pierced by a large, oblique, subovate or subelliptical foramen which encroaches upon the umbonal region, coming in contact with the delthyrium only at its apex. Internally the dental lamellæ are well developed and extend anteriorly from the beak with but slight divergence for about one-fourth the length of the valve.

Brachial valve nearly equally convex with the pedicle, the greatest convexity posterior to the middle, the umbo prominent, the surface curving abruptly to the posterior and postero-lateral margins, the curvature becoming more gentle to the antero-lateral and anterior margins;

FIG. 32.—A series of seven cross-sections of the rostral portion of the brachial valve of *Girtyella turgida* (× 2½), showing the median septum supporting the hinge-plate, and the manner of formation of the crura.

mesial portion of the valve depressed in a sinus originating in front of the umbonal region, which is somewhat broader, shallower and flatter than that of the pedicle valve, occasionally a slight, rounded rib occupies the median line of the sinus towards the front; the beak pointed and incurved beneath that of the opposite valve. Internally the socket plates are joined by a concave hinge-plate which is supported by a median septum, anteriorly the socket plates retreat from the lateral margins of the valve but are still joined together by the hinge-plate and are joined to the inner surface of the lateral slopes of the valve until they are continued into the free bases of the crura; the brachidium short, not reaching to the middle of the valve.

Surface of both valves sometimes nearly smooth but usually marked by concentric lines of growth which vary greatly in strength and distribution in different examples; shell structure finely punctate.

Remarks.—This species has frequently been misinterpreted, and three or more distinct species belonging to three different genera have commonly been known under this name. So far as it has been observed the species is always a small and rather gibbous form, but it varies greatly in its gibbosity and also in the development of the concentric lines of growth, the more gibbous examples commonly being most strongly marked by growth lines. The species differs from *G. indianensis*, the type of the genus *Girtyella*, in its shorter shell with more gibbous and usually less smooth valves, and in the much more conspicuous sinus of the brachial valve.

Horizon.—Salem limestone.

Girtyella indianensis (Girty)

Plate XXXIV, Figs. 1-24

1891. *Terebratula turgida* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 586, pl. 13, figs. 21-22.
1895. *Terebratula turgida* Whitfield, Geol. Surv. Ohio, vol. 7, p. 473, pl. 9, figs. 21-22.
1908. *Hartlina indianensis* Girty, Proc. U. S. Nat. Mus., vol. 34, p. 293, pl. 19, figs. 6-15.
1911. *Dielasma turgida* Morse, Proc. Ohio Acad. Sci., vol. 5, p. 381, figs. 12a-b.
1911. *Girtyella indianensis* Weller, Jour. Geol., vol. 19, p. 442, figs. 2a-i.

Description.—Shell small, longitudinally subovate, often approaching subpentagonal in outline, the greatest width a little in front of the middle, the anterior margin straightened or a little emarginate. The dimensions of two complete examples are: length of pedicle valve 13 mm. and 11.7 mm., length of brachial valve 12 mm. and 10.4 mm., width 10.2 mm. and 9.5 mm., thickness 8 mm. and 6 mm.

Pedicle valve most convex near or a little posterior to the middle, the surface curving abruptly towards the postero-lateral margins and becoming a little inflected to the cardinal extremities, curving less abruptly to the antero-lateral and anterior margins; mesial sinus obsolete in the umbonal region, rarely originating posterior to the middle, often being confined to the anterior third or fourth of the valve, shallow, rather narrow, rounded in the bottom and ill-defined laterally; the beak rather prominent and projecting well beyond that of the opposite valve, incurved, pierced by a large, longitudinally elliptical or subovate foramen which encroaches in its entirety upon the umbonal portion of the valve; the delthyrium and deltidial plates not visible externally because of the incurvature of the beak. Internally the dental lamellæ are well developed and extend nearly one-fourth the length of the valve anteriorly from the beak with a moderate degree of divergence.

Brachial valve a little less convex than the pedicle, the greatest convexity at or near the middle, the surface curving rather abruptly to the postero-lateral margins, arched from beak to front with the curvature

Fig. 33.—A series of four cross-sections of the rostral portion of the brachial valve of *Girtyella indianensis* (× 2½) from the Renault formation, showing the median septum and concave hinge-plate.

often a little more abrupt anteriorly; a mesial fold to correspond with the sinus of the opposite valve is rarely developed, when present it is narrow and obscure with a slight depression on either side and originates near the anterior margin, more commonly the median portion of

the valve is not differentiated at all, or an obscure sinus is present anteriorly, which, meeting the sinus of the opposite valve, produces a slight emargination of the shell; the beak pointed, closely incurved beneath that of the opposite valve. Internally a small, obscure, bilobed cardinal process is present at the apex of the valve, the dental sockets are formed by well-defined socket plates which are united by an imperforate, concave hinge-plate, supported by a median septum, anteriorly the socket plates retreat from the margins of the valves and are transformed into the bases of the crura which are still joined by the concave hinge-plate and are connected also with the inner surfaces of the lateral slopes of the valve; the median septum continues anteriorly, sometimes to near the middle of the valve, after it has become free from the hinge-plate; the brachidium short, not reaching the middle of the valve.

Surface of both valves smooth except for some concentric lines of growth which vary in strength and number in different individuals, sometimes being practically absent and again being well developed. Shell structure finely punctate.

Remarks.—This species occurs in abundance in the Pella beds of Iowa and elsewhere. It has usually been identified as *Diclasma turgida* and only recently has been described as a distinct species by Girty under the name *Harttina indianensis.* It was placed in the genus *Harttina* on account of the median septum of its brachial valve, but its brachidium is short like that of *Diclasma* and it cannot, therefore, be considered as *Harttina,* which has an elongate brachidium similar to that of *Cryptonella.* The combination of the short brachidium and the hinge-plate supported by a median septum has not hitherto been recognized as of generic value, but it is a stage of development essentially different from that of *Diclasma,* present in several well-defined species and is deemed to be worthy of recognition as of generic value.

The species differs from *G. turgida* in its more elongate form, less gibbous valves and in the usual absence or obsolesence of any median depression of the brachial valve.

Horizon.—Ste. Genevieve limestone and Chester Group.

Girtyella intermedia n. sp.

Plate XXXIV, Figs. 42-47

Description.—Shell small, ovate-subpentagonal in outline, the anterior margin truncate or a little emarginate, the greatest width near or a little anterior to the middle. The dimensions of two nearly complete specimens are: length of pedicle valve 13.8 mm. and 13.3 mm., length of brachial valve 12 mm. and 11.5 mm., greatest width 9.6 mm. and 9.9 mm., thickness 10 mm. and 8.5 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the surface curving strongly towards the postero-lateral margins

and inflected to the cardinal extremities, the curvature more or less abrupt to the antero-lateral margins; mesial sinus well developed, rather narrow, rounded or flattened in the middle, variable in depth, originating posterior to the middle of the valve sometimes well up on the umbo, its middle portion usually slightly produced in front in a short rounded extension; the beak prominent, strongly incurved, the foramen large, subovate, encroaching wholly upon the umbo. Internally the dental plates are well developed and elongate, reaching anteriorly from the beak for one-fourth or more than one-fourth the length of the valve.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface curving abruptly to the lateral margins; the mesial portion of the valve somewhat flattened posteriorly and more broadly flattened or slightly depressed in a shallow mesial sinus in front, near the front margin in the middle of the sinus or flattened region, is a narrow, rounded fold or plication which is variable in the strength of its development, when strongly developed in association with the rather narrowly rounded elevations at the sides of the sinus, it gives to the valve a marked triplicate appearance in front; the beak pointed and incurved beneath that of the opposite valve. Internally the socket plates are joined by the concave hinge-plate which is supported by a median septum, the crural lamellæ are not distinct from the socket plates, the free descending lamellæ of the brachidium being processes from the anterior extremity of the hinge-plate; the median septum is elongate and reaches anteriorly about two-fifths the length of the valve from the beak.

Surface of both valves marked only by concentric lines of growth which are usually obsolete posteriorly and are frequently obscure anteriorly. The shell structure finely punctate.

Remarks.—The more extreme specimens of this species are strikingly like examples of *Dielasma inflata* in the triplicate anterior extremity of the brachial valve, but they differ fundamentally from that species in the internal characters of the rostral portion of the brachial valve, besides having the convex curvature of the valves more regular than in that species, the abrupt geniculation of the valve being absent. As compared with other species of *Girtyella* this one is essentially intermediate in character between *G. turgida* and *G. brevilobata*. It has the strongly convex valves of *G. turgida* but lacks the broad, rounded sinus of the brachial valve which is so characteristic a feature of that shell, and has the narrow, rounded, mesial plication of the same valve more constantly present and more strongly developed. In this last feature the species is more nearly like *G. brevilobata*, but it is a shorter shell with more strongly convex valves than that species.

Horizon.—Chester Group, Paint Creek formation.

Girtyella brevilobata Swallow

Plate XXXIV, Figs. 37-41

1863. *Terebratula brevilobata* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 84.
1894. *Diclasma turgida* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 53, fig. 10 (not figs. 11-12).
1895. *Diclasma turgida* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 81, figs. 7-8 (not figs. 1-6).
1897. *Diclasma turgida* var. *elongata* Weller, Trans. N .Y. Acad. Sci., vol. 16, p. 260, pl. 18, fig. 6.
1911. *Harttina brevilobata* Girty, Bull. U. S. Geol. Survey No. 439, p. 65, pl. 2, fig. 12.
1911. *Girtyella brevilobata* Weller, Jour. Geol., vol. 19, p. 443.

Description.—Shell small, longer than wide, subpentagonal or subovate in outline, the greatest width near the mid-length, the anterior margin truncated or more usually emarginate. The dimensions of a nearly perfect example are: length of pedicle valve 12.5 mm., length of brachial valve 11.2 mm., width 10 mm., thickness 7.5 mm.

Pedicle valve most convex posterior to or near the middle, the surface curving abruptly to the antero-lateral margins, becoming inflected to the cardinal margins, curving more gently to the antero-lateral and anterior margins; mesial sinus usually well developed, originating near the umbonal region, narrow, rounded in the bottom, becoming rather deep anteriorly; the beak rather pointed, projecting notably beyond that of the opposite valve, incurved, pierced by a subovate or subelliptical foramen which encroaches entirely upon the umbonal region of the valve; the delthyrium and deltidial plates hidden by the incurvature of the beak. Internally the dental lamellæ are well developed and extend anteriorly with moderate divergence for one-fourth or a little more than one-fourth the length of the valve.

Brachial valve subequally convex with the pedicle, the greatest convexity near the middle, the surface arched from beak to front with the posterior slope a little more abrupt, curving abruptly to the lateral margins; at a point from one-third to one-fourth the length of the valve from the anterior margin a rather broad mesial sinus or depression originates, along the median line of which is a narrow, rounded fold, somewhat narrower than the sinus of the opposite valve, giving to the valve a distinctly trilobate contour with the median lobe smaller than the two outer ones and a little depressed between them; the beak pointed, strongly incurved beneath that of the opposite valve. Internally the socket plates are connected by a slightly concave hinge-plate which is supported by a median septum.

Surface of both valves smooth and unornamented except by concentric lines of growth which vary in the strength of their development in different individuals. Shell structure finely punctate.

Remarks.—The original description of this species is short and unaccompanied by illustrations, and the type specimen is believed to be lost, but the definition agrees so closely with the shell here illustrated that the identification is believed to be beyond question.

In size and convexity of the valves this species resembles *G. indianensis*, but it differs from that species in its somewhat more pentagonal outline, with the greatest width nearer the mid-length of the shell, and especially in the deeper, longer, and altogether more conspicuous mesial sinus of the pedicle valve and the short, broad sinus of the brachial valve with its distinct mesial fold or plication. This trilobation of the anterior margin of the brachial valve is sometimes faintly suggested in examples of *G. indianensis*, but it is never a conspicuous feature as in this species. The species differs from *G. turgida*, with which it has sometimes been identified, in its more elongate form and the less gibbosity of the valves, the trilobation of the anterior portion of the brachial valve is also a much more conspicuous feature, although that character is not infrequently present in *G. turgida*. The shell described as *Dielasma turgida* var. *elongata* Weller, is apparently a member of this species, the type specimen is an internal cast in which the median septum of the brachial valve is clearly seen, it is proportionally a little narrower and consequently more slender than is usual among typical representatives of *G. brevilobata*, but it possesses the long median sinus of the pedicle valve and the trilobation of the front of the brachial valve, although the trilobation is somewhat obscured by a slight distortion of the shell.

Horizon.—Chester group.

Genus *DIELASMELLA* Weller

Description.—Shell terebratuliform, compressed. Pedicle valve with well developed dental lamellæ of moderate length. Brachial valve without median septum or true hinge-plate, the socket plates well developed, retreating from the lateral margins of the valve anteriorly and becoming differentiated into two portions, a basal portion which joins the inner

FIG. 34.—A series of six cross-sections of the rostral portion of the brachial valve of *Dielasmella compressa* (× 2½), showing the development of the crura from the inner walls of the hinge sockets, and the narrow band joining the bases of the crura just before, and at the point, where they become free.

surface of the valve and is directed obliquely inward, and a distal portion which is abruptly bent in a subgeniculate angle so as to be directed obliquely outward, the portion included in the angular bend of the two plates is produced anteriorly into the bases of the crura, and just before

the crura become free a narrow transverse band joins their bases. The characters of the brachidium not completely determined, but it is clearly of the short, Dielasma-like type. Shell structure finely punctate.

Remarks.—In the arrangement of the internal features of the apical portion of the brachial valve this genus is perhaps more closely allied to *Cranaena* than to any other of the generic types here recognized. It differs from *Cranaena* chiefly in the reduction of the hinge-plate to a narrow transverse band joining the crural bases, while in *Cranaena* it is elongate with a comparatively small apical perforation and with the crura originating as a pair of ribs diverging anteriorly from near the apex. The difference in shape, viz: the much compressed shell and the erect beak of the pedicle valve are other features which easily separate the members of this genus from all the recognized species of *Cranaena*.

Dielasmella compressa Weller

Plate XXX, Figs. 43-55

1906. *Eunella compressa* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 442, pl. 6, figs. 13-16.
1911. *Dielasmella compressa* Weller, Jour. Geol., vol. 19, p. 447, figs. 7a-f.

Description.—Shell very small, lenticular, compressed, subovate in outline, usually longer than wide but sometimes a little wider than long, the greatest width near the mid-length of the shell. The dimensions of two complete specimens are: length of pedicle valve 5.9 mm. and 6 mm., length of brachial valve 5.1 and 5.5 mm., width 5 mm. and 6.5 mm., thickness 2 mm and 2.5 mm.

Pedicle valve depressed convex, the greatest convexity posterior to the middle, the surface usually very gently convex towards the lateral margins but sometimes a little compressed antero-laterally, near the postero-lateral margins the surface is abruptly inflected to the cardinal extremities; the median portion of the valve differentiated from the lateral slopes as a narrow, somewhat ill-defined, flattened region which is sometimes slightly depressed medially in a faint sinus; the beak pointed, nearly erect, pierced by a subcircular foramen which only partially encroaches upon the umbonal portion of the valve; delthyrium closed by a pseudodeltidium except in its apical portion which is a part of the foramen. Internally the dental lamellæ are well developed and are of moderate length.

Brachial valve equally or a little more convex than the pedicle, the greatest convexity posterior to the middle, the surface with a nearly straight slope along the median line from the middle of the valve to the front, convexly curved to the beak, the lateral slopes very gently convex and sometimes a little compressed towards the cardinal extremities; the median portion of the valve differentiated as a rather narrow, flattened

region similar to that of the opposite valve; the beak pointed, incurved beneath the base of the pseudodeltidium of the opposite valve. Internally the characters are in accord with the description of the generic characters already given.

Surface of both valves nearly smooth, marked only by fine, obscure, concentric lines of growth. Shell structure finely punctate.

Remarks.—This little species was originally described as a member of the genus *Eunella.* It agrees with *Eunella* in having a short brachidium, but it has not been possible to determine whether the loop is of the *Eunella* type, viz: with subparallel descending lamellæ, or whether it resembles the *Diclasma* loop in which the descending lamellæ are divergent. *Eunella,* however, is defined as having a distinct hinge-plate similar to that of *Cryptonella* or *Cranæna,* while in this species no true hinge-plate is present, as has been pointed out in the definition of the genus, the transverse connection between the bases of the crura being reduced to a narrow band.

Horizon.—Glen Park limestone of the Kinderhook.

Dielasmella calhounensis n. sp.

Plate XXXI, Figs. 1-4

Description.—Shell small, compressed, lenticular, subovate to ovate-subpentagonal in outline, longer than wide or sometimes about as long as wide, the greatest width near or a little anterior to the middle. The dimensions of a nearly complete specimen are: length of pedicle valve 10.5 mm., length of brachial valve 9.5 mm., greatest width 8.5 mm., thickness 4 mm.

Pedicle valve depressed convex, the greatest convexity near the umbo, the surface nearly flat or gently convex towards the lateral margins, abruptly inflected along the postero-lateral margins to the cardinal extremities; the mesial portion of the valve slightly flattened along an indefinite, rather narrow band from in front of the umbonal region to the anterior margin and frequently depressed along the median line of this band in a shallow but distinct median sinus; beak pointed, nearly erect, pierced by a subcircular foramen which encroaches largely upon the umbonal portion of the valve, only the margin being included in the delthyrium; the delthyrium entirely closed by deltidial plates except at its apex,

Fig. 35.—A series of seven cross-sections of the rostral portion of the brachial valve of *Dielasmella calhounensis* (× 2½), showing the development of the crural lamellæ from the inner walls of the hinge sockets, and the narrow band joining the bases of the crura just before they become free.

which is included in the foramen. Internally the dental lamellæ are well developed and of moderate length, their anterior extremities sometimes curving inward towards the median line of the valve.

Brachial valve a little more convex than the pedicle, the greatest convexity posterior to the middle, the surface curving somewhat abruptly from the umbonal region to the cardinal extremities and more gently to the lateral and anterior margins; the mesial portion of the valve flattened in a similar manner to the flattening of the opposite valve and not infrequently depressed in a distinct but shallow median sinus; the beak pointed, incurved beneath the base of the pseudodeltidium of the opposite valve. Internally the characters of the apical portion of the valve are in accord with the definition of the genus already given; the complete form of the brachidium not known.

Surface of both valves nearly smooth, only marked by concentric lines of growth which are frequently rather strong and crowded towards the anterior margin. The shell structure finely punctate.

Remarks.—This species is a close ally of *D. compressa* and perhaps should not be separated from it. It is always a larger form, however, with the brachial valve relatively more convex and with the median sinus of the pedicle valve more conspicuously developed. No examples have been observed in which the width exceeds the length, as sometimes happens in the smaller species, and the concentric growth lines are more strongly developed than in *D. compressa*. Most or all of these differential characters might perhaps be accounted for in the larger size of the individuals of *D. calhounensis*, but for the present, at least, the two forms will be considered as distinct. In the internal characters of the brachial valve upon which the genus is established, the two forms are essentially identical, the only difference being due to the greater compression of the valve in *D. compressa*.

Horizon.—Hamburg oolite of the Kinderhook.

Genus *HAMBURGIA* Weller

Description.—Shell terebratuliform, with well developed dental lamellæ in the pedicle valve. The brachial valve without cardinal process other than the slight thickening of the shell margin at the apex of the valve, the socket plates well developed, retreating from the lateral margins of the valve anteriorly beyond the articulation of the valves, and connected transversely by a deeply concave hinge-plate which is separated from the inner surface of the valve by an exceedingly low and broad cavity; upon the inner or concave side of the hinge-plate a pair of ridges originate towards the apex and diverge slightly while becoming stronger anteriorly, finally passing into the bases of the crura; shortly in front of the point of origin of the crural ridges on the hinge-plate the socket

plates are rapidly reduced in height and soon become obsolete, beyond which point the hinge-plate is not connected with the inner surface of the valve, but becomes a concave plate joining the bases of the crura and terminating anteriorly in a short distance. The complete form of the brachidium is not known, but it is probably short, not reaching the mid-length of the valve.

Remarks.—This genus is perhaps most closely allied to *Cranena*, from which it differs in the extreme concavity of the hinge-plate, the cavity between it and the inner surface of the valve being much reduced in height; accompanying the great depression of the hinge-plate is the absence of its perforation at the apex, which is, perhaps, the most diagnostic character. The genus is totally distinct from *Diclasma*, in which the crural plates originate as ridges upon the inner surface of the valve instead of upon the concave surface of the hinge-plate; the concave transverse plate between the bases of the crura is somewhat similar in the two genera except that it is not connected along its median line to the inner surface of the valve in *Hamburgia*, but in *Diclasma* the inner surface of this plate furnishes attachment for the adductor muscles which apparently is not true in *Hamburgia*.

HAMBURGIA TYPA Weller

Plate XXXI, Figs. 16-18

1906. *Cryptonella* ? sp. undet. Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 443.
1911. *Hamburgia typa* Weller, Jour. Geol., vol. 19, p. 446, figs. 6a-h.

Description.—Shell below medium size, subovate in outline, longer than wide, the greatest width near the mid-length, the postero-lateral margins nearly straight or gently convex, the antero-lateral and anterior margins semicircular. The dimensions of two detached pedicle valves are: length 17.8 mm. and 15.8 mm., width 14.8 mm. and 12 mm., convexity 4.7 mm. and 4.4 mm. The dimensions of a brachial valve are: length 14 mm., width 11.9 mm., convexity 4.4 mm.

Pedicle valve with the greatest convexity near or a little posterior to the middle, the surface arched from beak to front along the median line either nearly symmetrically or with a slightly increasing convexity posteriorly, the slope gently convex from the median line to the lateral margins, becoming a little inflected towards the cardinal extremities; mesial sinus obsolete, but the mesial portion of the valve is sometimes slightly flattened along an indefinite band; beak truncated, not strongly incurved, with a large, subcircular foramen which encroaches wholly upon the umbonal region, only the apex of the delthyrium being in contact with it; the delthyrium broadly triangular, completely closed by a pseudodel-

tidium except where it is filled by the incurved beak of the opposite valve. Internally the dental lamellæ are well developed and extend anteriorly from the beak for about one-fourth the length of the valve.

Brachial valve nearly equally or a little less convex than the pedicle, the greatest convexity near or a little posterior to the middle, the surface arched from the beak to the front with the convexity a little greater pos-

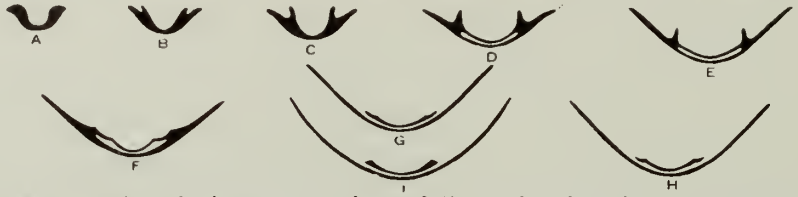

FIG. 36.—A series of nine cross-sections of the umbonal region of the brachial valve of *Hamburgia typa* (× 2½), showing the development of the deeply concave hinge-plate, with the crural ridges upon it.

teriorly, the lateral slopes convex, curving regularly from the median line to the lateral margins, the curvature being more abrupt posteriorly; mesial portion of the valve not differentiated from the general convexity; the beak pointed, incurved beneath that of the opposite valve. Internally the characters are in accordance with the generic description already given.

The surface of both valves is commonly marked by well-defined, concentric lines of growth which vary in different individuals in number and distribution. Shell structure minutely punctate.

Remarks.—This species is a common one in the fauna of the Kinderhook oolite at Hamburg, Illinois, and occurs also in the Glen Park limestone of Missouri. It resembles several species of Mississippian terebratuloid shells in which the fold and sinus are obsolete, but perhaps agrees more closely in external form with *Diclasma choutcauense* than with any other. It may be distinguished from that species, however, by the less incurved beak of the pedicle valve which is distinctly truncated, and usually by the more numerous and stronger concentric lines of growth. The internal characters of the rostral portion of the brachial valve are totally different, however, in these two species, and they are not even members of the same genus.

Horizon.—Hamburg oolite and Glen Park limestone of the Kinderhook.

Family ATRYPIDÆ

Genus *ATRYPA* Dalman

Description.—Shell subcircular in outline, strongly inequivalved with the brachial valve gibbous or with the valves subequally convex, the hinge-line short and the cardinal extremities rounded, surface radially plicate and usually marked also by more or less conspicuous, concentric,

lamellose lines of growth. Pedicle valve with a small, incurved beak with the foramen and delthyrium hidden except in young individuals; internally the hinge-teeth are large and widely separated, and the muscular impressions are sharply defined. In the brachial valve the crura are long, narrow and widely divergent, the jugum consists of two processes situated posteriorly at the junction of the crura with the primary lamellæ, directed towards the center of the shell and not joined at their inner extremities, the spirals have their bases subparallel with the inner surface of the pedicle valve, with their apices convergent towards the center of the brachial valve.

Remarks.—The genus *Atrypa* is commonly considered to have become extinct at the close of Devonian time, but it does persist into the Mississippian where it is limited to the Kinderhook division and is one of the rarest members of the fauna.

Atrypa infrequens n. sp.

Plate XXXV, Figs. 1-5

1906. *Atrypa spinosa* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 443, pl. 6, fig. 17.

Description.—Shell small, lenticular, subcircular in outline, the hinge-line very short. The dimensions of the holotype are: length of pedicle valve 7 mm., length of brachial valve 6.1 mm., greatest width 7 mm., length of hinge-line 3 mm., thickness 3.5 mm.

Pedicle valve depressed-convex, the greatest depth posterior to the middle, the umbo rather prominent with the surface sloping abruptly to the cardinal margin, and curving with gentle convexity to the lateral and anterior margins; mesial sinus absent; the beak obtusely pointed and produced posteriorly beyond the hinge-line nearly in line with the plane of the valve, only slightly incurved; cardinal area small, a little concave.

Brachial valve a little less concave than the pedicle, flattened in the umbonal region and a little compressed towards the cardinal extremities, the surface curving with a very gentle convexity to the lateral and anterior margins; the beak inconspicuous, scarcely projecting beyond the hinge-line.

Each valve marked by about fifteen rounded plications, a very few of which bifurcate in the umbonal region, they increase regularly in size distally, becoming very coarse at the outer margin of the shell; the plications are crossed by strong, regular, concentric lines of growth which are raised as lamellose extensions of the shell upon the tops of the plications.

Remarks.—This little shell has much the aspect of a small *A. spinosa* from the Middle Devonian, and was originally so identified. The single

specimen which has come under observation is apparently an adult individual, judging from the thickening of the valves at their free margins, and is many times smaller than adult examples of the Devonian *A. spinosa*. Size alone would perhaps not be a character upon which a species could be established, but in addition to this the brachial valve is considerably less convex than the pedicle, while in *A. spinosa* the brachial valve is the more convex.

Horizon.—Glen Park limestone of the Kinderhook.

Family SPIRIFERIDÆ

Genus *CYRTINA* Davidson

Description.—Shells small, semipyramidal in form, with usually non-plicated mesial fold and sinus, and simply plicated lateral slopes. Pedicle valve with a high, vertical or arched cardinal area which may be symmetrical or more or less distorted, the delthyrium narrowly triangular, closed with a convex pseudodeltidium which is perforated at a point below the apex by a subcircular, direct or oblique foramen, or may be without any opening. Internally the dental lamellæ are strongly developed and converge rapidly towards the inner surface of the valve, before meeting which they become joined in a single median septum which continues to the floor and extends anteriorly beyond the center, of the valve. Brachial valve very shallow, with narrow, inconspicuous cardinal area. Internally the cardinal area consists of a double apophysis from the sides of which diverge the strong crural plates; the spiral cones are directed obliquely towards the middle of each lateral slope of the pedicle valve, the jugum is continuous, its branches being directed upward and forward, uniting at their extremities. Shell substance strongly punctate.

Remarks.—The genus *Cyrtina* has its greatest development in the Devonian faunas, being represented in only the earlier portion of Mississippian time. It differs from *Spiriferina*, another strongly punctate shell, in the union of the dental lamellæ to form a spondylium supported by a median septum, as well as in the more conspicuous semipyramidal form of the shell.

CYRTINA ACUTIROSTRIS (Shumard)

Plate XXXV, Figs. 6-21

1855. *Cyrtia acutirostris* Shumard, Geol. Rep. Mo., p. 204, pl. C, figs. 3a-c.
1894. *Cyrtina acutirostris* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 29, fig. 18.
1894. *Cyrtina acutirostris* Keyes, Mo. Geol. Surv., vol. 5, p. 89, pl. 39, figs. 10a-b.
1895. *Cyrtina acutirostris* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 28, figs. 38-42, 44, 54.

1908. *Cyrtina acutirostris* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 84, pl. 18, figs. 16-20; p. 87, pl. 19, fig. 2.

Description.—Shell small, subpyramidal in form, broader than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of two examples are: length of pedicle valve 13.4 mm. and 7.3 mm., length of brachial valve 8.2 mm. and 6.2 mm., width 15.6 mm. and 11 mm., thickness 10 mm. and 6.9 mm., height of cardinal area 5.7 mm. and 5.1 mm.

Pedicle valve subpyramidal with the apex nearly erect or curved towards the hinge-line in various degrees; the surfaces of the lateral slopes unusually convex throughout and sloping steeply from the umbo to the lateral and antero-lateral margins, sometimes a little compressed along the cardinal margin towards the cardinal extremities; mesial sinus shallow or of moderate depth, originating at the beak, rounded or subangular in the bottom; the cardinal area high, nearly flat in the younger shells and lying at an angle of from 60 to 90 degrees to the plane of the valve, remaining nearly flat or becoming more or less strongly arched in full grown shells, the lateral margins are sharply defined and angular, and slope in nearly straight lines or are gently convex from the beak to the cardinal extremities; the delthyrium is high and narrow and is covered by a convex pseudodeltidium which is pierced by an elongate, narrow foramen sometimes reaching from the apex more than half way to the cardinal margin; each lateral slope is marked by three or four simple plications originating along the cardinal margin, the two bounding the mesial sinus are much the strongest, the others rapidly becoming much narrower and weaker. Internally a strong median septum reaches from the beak half way to the front margin of the valve, towards the cardinal area the septum is flanked by the rather short dental plates which reach from the margins of the delthyrium; in the angle formed by the junction of the dental plates with the median septum an angular ridge extends from the apex of the delthyrium to the free margin of the septum and in front of this ridge between the laminæ of the septum is a pair of laterally compressed canals placed side by side and extending from near the apex of the valve to the free margin of the septum; the muscular scars are feebly developed, and the muscles were probably attached in large part to the sides of the septum.

Brachial valve depressed convex, very shallow, compressed towards the cardinal extremities, the greatest convexity near the middle; the mesial fold low or sometimes moderately elevated as it approaches the front margin, non-plicate or with a slight mesial depression which is sometimes present only towards the beak; each lateral slope marked by three or four plications, the first of which adjacent to the mesial fold is nearly as broad as the fold itself, the others much smaller, the last one often being nearly

obsolete; the cardinal area linear. Internally the valve is thickened towards the cardinal margin, the cardinal process is bifid and from it a pair of crural plates or ridges diverge anteriorly and curve towards the lateral margins of the valve with the hinge sockets excavated from the sides; the muscle scars occupy a suboval area which does not extend laterally beyond the boundaries of the mesial fold and which extends anteriorly to beyond the middle of the valve.

Surface of both valves marked by rather strong, concentric lines of growth which are frequently crowded at intervals, especially towards the front. Shell substance finely punctate.

Remarks.—This is one of the most characteristic species in the fauna of the Louisiana limestone. It may be easily distinguished from other members of the genus by the broad plications on each side of the fold and sinus. On the brachial valve these plications are frequently nearly as wide as the mesial fold itself, while the ones beyond are much narrower.

Horizon.—Louisiana limestone.

Cyrtina burlingtonensis Rowley

Plate XXXV, Figs. 22-31

1893. *Crytina burlingtonensis* Rowley, Am. Geol., vol. 12, p. 308, pl. 14, figs. 15-17.

1909. *Cyrtina burlingtonensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 310, pl. 13, figs. 20-23.

Description.—Shell small, obliquely subpyramidal in form, the hinge-line usually a little shorter than the greatest width of the shell, and the cardinal extremities a little rounded. The dimensions of two nearly perfect specimens are: length of pedicle valve 13.2 mm. and 9.6 mm., length of brachial valve 9 mm. and 6.7 mm., width 12.8 mm. and 9.5 mm., thickness 9 mm. and 6.5 mm., height of cardinal area 5 mm and 3.3 mm., length of hinge-line 11.6 mm. and 7.5 mm. The dimensions of the holotype are: length of pedicle valve 10.5 mm., length of brachial valve 7.5 mm., greatest width 11.1 mm., thickness 7.2 mm., height of cardinal area 3.6 mm., length of hinge-line 8.5 mm.

Pedicle valve very deep, obliquely subpyramidal, the lateral slopes convex to the cardinal extremities; the mesial sinus shallow and narrow, originating at the beak, rounded or subangular in the bottom; the beak sharply pointed and incurved over the cardinal area; cardinal area high, triangular, usually strongly arched with the curvature becoming greater towards the beak, the lateral margins not sharply defined but rounding regularly into the lateral slopes of the valve; the delthyrium high and narrow, covered by a convex pseudodeltidium which is pierced by a rather small, longitudinally subelliptical foramen situated close under the beak, or in some cases apparently imperforate; each lateral slope of the

valve is marked by three or four rounded plications which originate at the cardinal margin, the two plications bounding the sinus are much the stronger, the outermost ones becoming much less distinct and sometimes nearly obsolete. Internally a strong median septum reaches nearly or quite half way from the beak to the front margin.

Brachial valve depressed convex, sometimes nearly flat, compressed towards the cardinal extremities; mesial fold rounded, originating at the beak, scarcely elevated above the plications on either side; each lateral slope marked by two or three plications, the outermost ones being more or less indistinct. Internal characters not observed.

Besides the plications the surface of both valves is marked by concentric lines of growth which are frequently rather strong and somewhat crowded towards the front margin. Shell structure minutely punctate.

Remarks.—The shell which has been identified as *C. burlingtonensis* occurs most commonly in the Chouteau limestone fauna. It differs from *C. acutirostris* of the Louisiana limestone in its narrower and more elongate form with more attenuate beak, in the rounded lateral margins of the cardinal area, and in the comparatively narrower plications next to the mesial fold of the brachial valve. The species was originally described by Rowley from the white cherts at the base of the Burlington limestone at Louisiana, Missouri, and it has been recognized in the Fern Glen fauna.

Horizon.—Chouteau limestone, Fern Glen formation and base of the Burlington limestone.

CYRTINA NEOGENES Hall and Clarke

Plate XXXV, Figs. 32-38

1895. *Cyrtina* sp. ? Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 39, figs. 25-28.

1895. *Cyrtina neogenes* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 84, fig. 41.

1897. *Cyrtina neogenes* Hall, 14th Rep. N. Y. State Geol., p. 372, pl. 8, figs. 4-8.

Description.—Shell below medium size or small, broader than long, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of two specimens are: length of pedicle valve 15 mm. and 7.1 mm., length of brachial valve 11 mm. and 6.5 mm., width 16.8 mm. and 11 mm., thickness 14 mm. and 6 mm., length of hinge-line 13 mm. and 8.7 mm., height of cardinal area 5.5 mm. and 2.3 mm.

Pedicle valve strongly convex, the convexity extending out to the cardinal extremities; the mesial sinus sharply defined, non-plicate, rather deep and of moderate width, subangular in the bottom; cardinal area rather high, concave, becoming more strongly arched towards the beak,

the lateral margins in the internal casts rounding regularly into the lateral slopes of the shell; the delthyrium narrowly triangular with no indication of deltidial plates in the casts, although such were probably present; each lateral slope marked by from six to eight, simple, rounded or subangular plications which originate at the cardinal margin, becoming regularly less conspicuous laterally, the outermost ones sometimes becoming almost obsolete. Internally a strong median septum extends from the beak half way to the anterior margin, the dental plates are short and join the median septum to form a spondylium, muscular scars obscure.

Brachial valve less convex than the pedicle, the convexity extending out to the cardinal extremities and greatest near the middle; mesial fold nonplicate, rounded, of moderate width, bounded by deep rounded furrows, only moderately elevated above the general surface of the valve; each lateral slope marked by from five to seven simple, rounded plications entirely similar to those of the opposite valve. Internally the muscular scars are obscure, the only marking shown upon the internal casts being a slight median ridge which extends from the beak anteriorly to about the middle of the valve; the cardinal process is of moderate size and is flanked by the diverging crural plates.

Besides the plications the surface of each valve is marked by fine, regular, sublamellose, imbricating, concentric lines of growth, about three occupying the space of one millimeter. Shell structure thickly and rather coarsely punctate, the perforations being arranged in the central portion of the valves, and perhaps also laterally, in regular concentric lines corresponding with the depressions between the external markings of the shell.

Remarks.—This species has been observed only as internal casts and external moulds, from residual cherts at Springfield and elsewhere in Missouri, the type specimens of the species being from that locality rather than from Burlington, Iowa, as stated by the authors of the species. The proper horizon of the species is also incorrectly recorded in the original description, the horizon as indicated by associated species in the cherts, being as high as Keokuk rather than the Burlington.

In its general form and surface markings the species resembles some members of the genus *Spiriferina* much more closely than other members of the genus *Cyrtina*. It especially resembles some shells from the Salem limestone fauna which has been commonly identified as *Spiriferina spinosa*, but it has a little less angular plications, and the cardinal margins of the pedicle valve are not sharply defined, but round regularly from the lateral slopes into the cardinal area. Internally the species is fundamentally different from *Spiriferina*, in the union of the dental plates in a spondylium supported by a median septum. The punctate shell structure

is clearly shown in the chert specimens by the little siliceous pillars which join the two surfaces of the cavity left by the solution of the shell, these pillars being the casts of the perforations which penetrated the shell through its entire thickness, unless a thin epidermal imperforate layer was removed before the shells were fossilized.

Horizon.—Residual chert, probably Keokuk age.

Genus *SPIRIFERINA* d'Orbigny

Description.—Shells usually small, spiriferoid in form, transverse, the greatest width usually along the hinge-line and the cardinal extremities acutely angular; mesial fold and sinus well developed, either non-plicate or with a single median plication; lateral slopes of the valves covered with simple plications, and the whole shell marked by sublamellose, concentric lines of growth. Pedicle valve with a moderately high, arched cardinal area having an open delthyrium; internally the dental plates are well developed and continue to the inner surface of the valve along the lateral margins of the muscular scar, between them a well developed median septum is present which extends further anteriorly than the dental lamellæ and may reach beyond the center of the valve. In the brachial valve the spiral cones are directed laterally as in *Spirifer*, the primary lamellæ being joined by a simple transverse or subacute jugum. Shell structure strongly punctate throughout.

Remarks.—Externally the members of this genus are not unlike some small species of the genus *Spirifer*, the essential characters by which they are differentiated from that genus being the punctate shell structure and the very strong median septum in the pedicle valve. From the genus *Delthyris*, *Spiriferina* differs essentially only in the punctate shell structure, and a number of Mississippian species which have been commonly referred to *Spiriferina* heretofore, but in which no punctate shell structure has been detected, are transferred to *Delthyris* in the present report.

SPIRIFERINA SUBTEXTA White

Plate XXXVI, Figs. 35-40

1862. *Spiriferina ? subtexta* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 25.
1901. *Spiriferina subtexta* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 199, pl. 20, figs. 5-6.
1909. *Spiriferina subtexta* Weller, Bull. Geol. Soc. Am., vol. 20, p. 309, pl. 13, figs. 16-19.

Description.—Shell small, wider than long, the hinge-line usually a little shorter than the greatest width of the shell, and the cardinal extremities usually abruptly and narrowly rounded. The dimensions of a nearly perfect pedicle valve are: length from front to beak 10.5 mm., width

15.5 mm., length of hinge-line 13.5 mm., height of cardinal area 3.5 mm.

Pedicle valve with a prominent umbo, the surface curving rather abruptly anteriorly to the front margin and more gently laterally, slightly or not at all compressed towards the cardinal extremities; mesial sinus sharply defined, originating at the beak, of moderate depth and width, subangular at the bottom; beak rather sharply pointed, incurved; cardinal area rather high, nearly flat below and lying in nearly a right angle to the plane of the valve, becoming concave above, the curvature increasing towards the beak, the surface abruptly rounding into the lateral slopes of the valve along the lateral margins; the delthyrium narrowly triangular, higher than wide; each lateral slope bearing from seven to nine simple, rounded or subangular plications which originate near the cardinal margin and grow successively smaller towards the cardinal extremities, the last two or three usually being very faint.

Brachial valve depressed convex, much shallower than the pedicle, its greatest convexity near the middle, compressed towards the cardinal extremities; mesial fold sharply defined, rounded on top, only moderately elevated above the general surface of the valve; beak small and inconspicuous, scarcely reaching beyond the cardinal margin; cardinal area very narrow, lying in nearly the plane of the valve; lateral slopes bearing plications similar to those of the opposite valve and alternate with them.

Besides the plications, each valve is ornamented by fine, regular, concentric, sublamellose, imbricating markings, about three or four of which occupy the space of one millimeter. When the shell is perefectly preserved the surface of each of these concentric lamellæ is regularly fimbriate. The shell structure finely and closely punctate.

Remarks.—This species is characterized by its rather high area and the absence of a median plication in the fold and sinus. The fimbriated character of the fine concentric markings of the shell has been observed on but a single example, but it was doubtless characteristic of all during life. The punctate structure of the shell is also usually obscure but can usually be detected upon some specimens of any collection by close examination with a lens. The internal characters of the shell have not been observed, but they doubtless conform with other members of the genus.

Horizon.—Kinderhook.

Spiriferina solidirostris White

Plate XXXVI, Figs. 25-34

1860. *Spirifer solidirostris* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 232.
1862. *Spiriferina solidirostris* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 24.
1865. *Spiriferina solidirostris* Winchell, Proc. Acad. Nat. Sci. Phil., p. 120.

1899. *Spiriferina solidirostris* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 545, pl. 71, fig. 10a.
1901. *Spiriferina solidirostris* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 198, pl. 20, figs. 2-4.
1903. *Spiriferina solidirostris* Girty, U. S. Geol. Survey, Prof. Paper No. 16, p. 294, pl. 1, figs. 3-4.

Description.—Shell below medium size, wider than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a pedicle valve are: length from umbo to front margin 12.5 mm., width along the hinge-line 15 mm., convexity 6.7 mm., height of cardinal area 3 mm.

Pedicle valve with a broad, prominent umbo, the surface curving rather abruptly to the anterior margin and sloping to the cardinal extremities with a slightly sigmoidal curve, becoming slightly compressed towards the cardinal extremities; mesial sinus sharply defined, originating at the beak, of medium width and depth, marked in the bottom by a single, angular, median plication which originates in the posterior half of the valve; the beak pointed and strongly incurved; the cardinal area rather high, nearly flat below and lying almost at a right angle to the plane of the valve, becoming concave above and strongly arched towards the beak, the apical portion sometimes being so much incurved as to be directed almost towards the hinge-line; delthyrium rather large, usually higher than wide, often retaining the pseudodeltidial covering towards the apex; lateral slopes marked by from six to eight, strong, simple, rounded plications which originate along the cardinal margin, those bounding the sinus are the strongest, the lateral ones becoming progressively smaller towards the cardinal extremities. Internally the apical portion of the valve is much thickened and solidified, and the rather strong median septum extends to about the middle of the valve, the dental plates are rather short and thick and the muscular scars are inconspicuous.

Brachial valve depressed convex, much less convex than the opposite one, the greatest convexity usually near the middle, the surface somewhat compressed towards the cardinal extremities; the mesial fold sharply defined, originating at the beak, moderately elevated above the general surface of the valve, flattened on top and marked by a single, simple, mesial furrow; the beak inconspicuous and scarcely extending beyond the cardinal margin; the cardinal area very narrow; lateral slopes marked by plications similar to those of the opposite valve and alternate with them. Internal characters not observed.

Besides the plications each valve is ornamented by regular, concentric, sublamellose, imbricating markings, about two or three of which occupy the space of one millimeter. The shell structure is punctate.

Remarks.—This species of *Spiriferina* may be recognized by its prominent umbo, strongly incurved beak of the pedicle valve, strongly arched cardinal area, and especially by the median plication of the fold and sinus. Both the plications and concentric markings are somewhat coarser than the same features in *S. subtexta.* In no case have the concentric lamellæ given evidence of being fimbriate upon any of the specimens observed, as is the case in *S. subtexta,* but this is a character which is easily destroyed and the shells may have possessed it when living. The punctate structure of the shell is commonly obscure or indeterminable upon the specimens, but occasional examples, exfoliated wholly or in part, show the presence of the perforations.

Horizon.—Kinderhook.

Spiriferina subelliptica (McChesney)

Plate XXXVI, Figs. 54-57

1860. *Spirifer subelliptica* McChesney, Desc. New Pal. Foss., p. 43.
1894. *Spiriferina subelliptica* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 2, fig. 2.
1895. *Spiriferina subelliptica* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 35, figs. 21-22.

Description.—Shell of medium size or somewhat larger, transversely subelliptical in outline, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded, the greatest width posterior to the mid-length. The dimensions, subject to error, of a nearly complete but somewhat crushed specimen, are: length of pedicle valve 19.5 mm., length of brachial valve ±17 mm., greatest width 28.5 mm., thickness estimated±12 mm., length of hinge-line 22.5 mm., height of cardinal area 3.5 mm., width of sinus in front 11.4 mm.

Pedicle valve most prominent towards the umbo, compressed toward the cardinal extremities; mesial sinus sharply defined, non-plicate, originating at the beak, of moderate depth and rounded in the bottom; beak rather small, pointed and incurved; cardinal area moderately high, concave with the curvature increasing towards the beak, sometimes the surface of the area rounds into the lateral slopes of the valve with but a slight limiting ridge, but more often the lateral margins are well defined; delthyrium rather large, as high or higher than wide; each lateral slope marked by from seven to eleven simple, rounded plications which originate near the cardinal margin and grow successively smaller towards the cardinal extremities, the last two or three sometimes being very faint. Internally the shell is much thickened in the apical region, a strong median septum is present which reaches to about the middle of the valve, the dental plates are strong and short, the muscular scars are rather small and only moderately distinct.

Brachial valve less convex than the pedicle, most convex posterior to the middle, the surface curving rather abruptly to the cardinal margin and gently to the anterior margin, somewhat compressed towards the cardinal extremities; mesial fold only moderately elevated above the general surface of the valve, originating at the beak, sharply defined, rounded on top; beak very small, scarcely or not at all extended beyond the cardinal margin; cardinal area very narrow; the lateral slopes marked by plications similar to those of the opposite valve and alternate with them. Internally the cardinal process is small and inconspicuous, the crural plates are rather strong with the dental sockets excavated from their outer surfaces; the muscular scars are narrow and deeply excavated, with a thickened, marginal, bordering ridge on each side which continues to the anterior margin of the valve.

Surface of each valve, in addition to the plications, ornamented by fine but strong, regular, sublamellose, imbricating, concentric markings which are finely but distinctly fimbriate, from three to four of these markings occupy the space of one millimeter. Shell structure minutely and closely punctate.

Remarks.—This species has been rarely recognized since its original description without illustrations, by McChesney. It is not an uncommon form from the "Button Mould Knobs" of Kentucky, but its horizon is Kinderhook rather than Kaskaskia, as stated by McChesney. The species is the largest member of the genus in the faunas here considered, and also differs from all the other of our species, except *S. subtexta*, in the finely fimbriate concentric markings of the shell.

Horizon.—New Providence shale of Kinderhook, Button Mould Knobs, Kentucky.

Spiriferina norwoodana (Hall)

Plate XXXVI, Figs. 41-48

1856. *Spirifer norwoodana* Hall, Trans. Albany Inst., vol. 4, p. 7.
1882. *Spiriferina Norwoodana* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 48, pl. 6, figs. 16-17.
1883. *Spiriferina norwoodana* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 327, pl. 29, figs. 16-17.
1906. *Spiriferina norwoodana* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1311, pl. 22, figs. 16-17.

Description.—Shell small, subsemielliptical in outline, wider than long, the hinge-line a little shorter than the greatest width of the shell, the greatest width posterior to the mid-length of the shell, the cardinal extremities rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 3.1 mm., length of brachial valve 3 mm., width 4 mm., length of hinge-line 3.1 mm., thickness 2.8 mm., height of cardinal area .8 mm., width of sinus in front 1.4 mm.

Pedicle valve strongly convex, most prominent near the umbo, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, sometimes slightly compressed towards the cardinal extremities; mesial sinus originating at the beak, of moderate width and depth, rounded in the bottom; beak small, pointed or moderately blunt, incurved; cardinal area small, concave, the lateral margins ill-defined, rounding into the lateral slopes of the valve; delthyrium about as wide as high; each lateral slope marked by from three to five, simple, rounded plications, which originate at or near the cardinal margin, those bounding the mesial sinus are much the stronger, the last ones towards the cardinal extremities being very faint or almost obsolete. Internally, the median septum is reduced to a slight ridge which extends anteriorly from the beak for about one-third the length of the valve, the dental plates are weakly developed, being little more than a thickening of the valve along the inner margin of the delthyrium.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the surface a little compressed towards the cardinal extremities; mesial fold well defined, rounded, but little elevated above the general surface of the valve, sometimes with a slight mesial depression towards the front; beaks very small and incurved; the cardinal area very narrow; plications similar to those of the opposite valve and alternate with them.

Surface of both valves, when well preserved, marked by minute papillæ. Towards the front of the shell one or more concentric lines of growth are frequently present. Shell structure minutely punctate.

Remarks.—The specimen whose dimensions have been given above is one of the largest members of the species which has come under observation of the writer. The type specimens of the species, however, include somewhat larger individuals, the maximum dimensions recorded by Hall being length 4.5 mm. and width 5.25 mm. The species has been compared with *S. spinosa* by Whitfield, who seems to have held the opinion that it might be only a diminutive form of that species. It resembles *S. spinosa* in the surface ornamentation of the shell, but besides being so much smaller, *S. norwoodana* is more rounded at the cardinal extremities, has a much less sharply defined cardinal area, and more broadly rounded plications, and it is believed that the two forms are clearly distinct specifically.

Horizon.—Salem limestone.

Spiriferina salemensis n. sp.

Plate XXXVI, Figs. 1-5

Description.—Shell below medium size, broader than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly perfect specimen are: length of pedicle valve 16.3 mm.,

length of brachial valve 12.8 mm., width along hinge-line 22 mm., thickness 13.3 mm., height of cardinal area 5.8 mm., width of sinus in front 6 mm.

Pedicle valve strongly convex, most prominent on the umbonal region, the surface curving steeply from the umbo to the anterior margin and more gently to the cardinal extremities; mesial sinus angular or subangular, sharply defined, originating at the beak, of moderate depth and width; beak small, a little incurved; cardinal area large and high, nearly flat below and lying in nearly a right angle to the plane of the valve, concave above with an increasing curvature to the beak, the lateral margins usually sharply defined; the delthyrium large, much higher than wide; each lateral slope marked by about five, simple, angular or subangular plications which originate along the cardinal margin. Internally a strong median septum reaches anteriorly from the beak for about one-third the length of the valve, the dental plates diverge anteriorly from the beak and extend about one-half as far as the median septum; muscular scars obscure.

Brachial valve less convex than the pedicle, highest at or near the front of the mesial fold, the surface sloping from the front margin of the fold to the beak in an increasingly convex curve, becoming a little compressed towards the cardinal extremities; mesial fold angular, sharply defined, much elevated in front; cardinal area very narrow, lying in nearly a right angle to that of the opposite valve; the beak small, incurved; each lateral slope marked by angular plications similar to those of the opposite valve and alternate with them.

Surface of both valves marked by numerous, concentric lines of growth, irregular in strength and crowded at intervals towards the front to form stronger growth lines. Shell structure minutely punctate.

Remarks.—This is the more common species of *Spiriferina* in the fauna of the Salem limestone, and has sometimes been identified as *S. spinosa*. It differs from that species in its much more elevated cardinal area, in its more angular plications, more elevated mesial fold in front, and in the very different style of surface markings. It is very different from the diminutive *S. norwoodana* of the same fauna, and cannot be considered as a larger form of the same species.

Horizon.—Salem limestone.

Spiriferina transversa (McChesney)

Plate XXXV, Figs. 41-49

1860. *Spirifer transversa* McChesney, Desc. New Pal. Foss., p. 42.
1865. *Spirifer transversa* McChesney, Ill. New Spec. Foss., pl. 6, figs. 3a-e.
1868. *Spirifer transversa* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 34, pl. 6, figs. 3a-e.
1874. *Spiriferina transversa* Derby, Bull. Cornell Univ. (Science), vol. 1, No. 2, p. 21, pl. 2, figs. 4, 6, 13; pl. 3, figs. 12, 14, 17; pl. 5, fig. 4.

1883. *Spirifera transversa* Hall, Rep. N. Y. State Geol. for 1882, pl. (35) 60, figs. 19-25.
1894. *Spiriferina transversa* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 31, figs. 1-3.
1895. *Spiriferina transversa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 35, figs. 19, 20, 23-25.

Description.—Shell below medium size, broadly subtriangular in outline, usually more than twice as wide as long and the thickness about equal to the length, the cardinal extremities acutely pointed. The dimensions of a very perfect specimen are: length of pedicle valve 10 mm., length of brachial valve 9 mm., width along hinge-line 25.1 mm., thickness 9.6 mm., height of cardinal area 3 mm., width of mesial sinus in front 4.2 mm.

Pedicle valve strongly convex, most prominent in the umbonal region, the surface sloping from the umbo to the cardinal extremities in a nearly straight or slightly concave line and curving strongly to the anterior margin; the mesial sinus originating at the beak, of moderate width and depth, sharply defined, marked by a single median plication which originates in the umbonal region; the beak rather small, pointed and incurved; cardinal area large, concave, with the curvature increasing towards the beak, its lateral margins sharply defined, its lower, flatter portion standing at nearly a right angle to the plane of the valve; delthyrium large, nearly as wide as high; each lateral slope marked by from ten to twelve simple, rounded plications which originate along the cardinal margin, those bounding the mesial sinus are the largest and they grow regularly smaller towards the cardinal extremities, the last ones being very faint or nearly obsolete. Internally a strong median septum extends from the beak to about the middle of the valve, the hinge-teeth are strengthened by dental lamellæ which continue to the floor of the valve and diverge anteriorly, extending about one-half or a little less than one-half as far as the median septum.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly from the point of greatest convexity to the cardinal margin and more gently to the anterior margin, towards the cardinal extremities the surface is somewhat compressed; mesial fold sharply defined, originating at the beak, flattened on top and marked by a median furrow which originates back of the middle of the valve; the beak small, strongly incurved; the cardinal area very narrow, making an angle of about 90 degrees to that of the opposite valve; each lateral slope marked by plications similar to those of the opposite valve and alternate with them. Internally, the cardinal process is of moderate size and is flanked by the rather strong crural plates in the outer faces of which the dental sockets are excavated; the muscular scars are weakly developed and are divided longitudinally by a faint median ridge.

In addition to the plications the surface of each valve is marked by fine, regular, imbricating, sublamellose lines, about four of which occupy the space of one millimeter. The shell substance is finely punctate, the perforations having a tendency to be arranged in concentric lines, although this arrangement is not perfectly carried out.

Remarks.—This species may be easily recognized by the great width of the shell and by the mesial plication in the fold and sinus. In this latter character it resembles *S. solidirostris* from a much lower horizon in the Mississippian, and occasionally an individual with less extended hinge-line than common, rather closely resembles the earlier species, but ordinarily *S. transversa* has somewhat finer plications than *S. solidirostris,* and a narrower umbonal region. The chief variation shown by different individuals of the species is in the proportional width of the shell. The specimen whose dimensions have been given is an entirely normal individual, but occasionally examples occur whose length is fully two-thirds the width, but they possess the characters of the species in all other respects and are united with the normal form by intermediate variations.

Horizon.—Chester group.

Spiriferina spinosa (Norwood and Pratten)

Plate XXXV, Figs. 50-58

1855. *Spirifer spinosus* Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., (2), vol. 3, p. 71, pl. 9, figs. 1a-d.
1858. *Spirifer spinosus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 706, pl. 27, figs. 5a-e.
1883. *Spiriferina spinosa* Hall, Rep. N. Y. State Geol. for 1882, pl. (35) 60, figs. 26-29.
1894. *Spiriferina spinosa* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 31, figs. 4-7.
1894. *Spiriferina spinosa* Keyes, Mo. Geol. Surv., vol. 5, p. 85.
1895. *Spiriferina spinosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 35, figs. 26-29.

Description.—Shell below medium size, broader than long, the greatest width along the hinge-line or a little anterior to it, the cardinal extremities angular or a little rounded. The dimensions of two perfect specimens are: length of pedicle valve 14.2 mm. and 12.5 mm., length of brachial valve 11.5 mm. and 10.3 mm., width 18.7 mm. and 20.4 mm., thickness 12.5 mm. and 9.8 mm., height of cardinal area 2.6 mm. and 2.4 mm., width of mesial sinus in front 6.1 mm. and 5.3 mm.

Pedicle valve most convex posterior to the middle, the umbo prominent, the surface curving abruptly to the cardinal margin and more gently to the anterior margin, often a little compressed towards the cardinal extremities; the mesial sinus sharply defined, originating at the beak, of moderate width and rather deep, subangular in the bottom; the beak

rather small, pointed and incurved; cardinal area of moderate height, concave with the curvature increasing towards the beak, the lower and flatter portion lying at nearly a right angle to the plane of the valve, the lateral margins well defined but rounding rather abruptly to the lateral slopes of the valve; delthyrium about as wide as high; each lateral slope marked by five or six rounded or subangular, simple plications, which originate along the cardinal margin, those bounding the mesial sinus are the strongest, the others becoming successively smaller to the cardinal extremities. Internally a strong median septum reaches from the beak to more than one-third the length of the valve, the hinge-teeth are supported by dental plates which diverge anteriorly and extend about one-third as far as the median septum.

Brachial valve nearly or quite as convex as the pedicle, the greatest depth near the middle or towards the front of the mesial fold; the surface convex on each side of the fold, usually becoming a little compressed towards the cardinal extremities; mesial fold rounded or subangular, sharply defined, moderately or rather highly elevated in front; the beak small and incurved; the cardinal area very narrow, lying in nearly the plane of the valve; the plications on the lateral slopes are similar to those of the opposite valve and alternate with them.

Surface of both valves, when well preserved, marked by crowded tubercles which are the bases of spinules which are scattered in position or sometimes are arranged in rather irregular radiating rows. One or more rather strong lines of growth are sometimes present towards the anterior margin of the valves. Shell substance punctate.

Remarks.—This species occurs commonly in some of the Chester faunas and can be easily recognized by the character of the surface markings. It may be easily distinguished from *S. transversa,* with which it is sometimes associated, by its proportionally narrower and longer shell, by the absence of a median plication in the fold and sinus, and by its surface markings.

Horizon —Chester group

Genus *DELTHYRIS* Dalman

Description.—Shell small or of medium size, spiriferoid in external form, the mesial fold and sinus non-plicate or with a single median plication, the lateral slopes of the valves with simple, rather strong plications, both valves marked by concentric, lamellose lines of growth of greater or less strength. Pedicle valve with an arched cardinal area of moderate height, and an open delthyrium; internally the dental lamellæ are well-develpoed and between them is a well-defined median septum. The brachial valve is similar to *Spirifer* internally, with a brachidium as in that genus.

Remarks.—The genus *Delthyris* commonly has not been recognized above the Devonian, but there is a group of small *Spiriferina*-like shells in our

early Mississippian faunas which are apparently wholly devoid of punctate shell structure and must consequently be excluded from *Spiriferina*, and the genus *Delthyris* is apparently the only place where they can be properly located. The only essential difference between *Delthyris* and *Spiriferina*, as interpreted by Schuchert,[1] and followed by the author, is in the absence of punctation in *Delthyris*. Both genera are characterized by the well developed median septum in the pedicle valve, by the simple plications of the shell, by the strong, concentric, lamellose lines of growth, and by the essentially spiriferoid external form. It is believed that the shells here placed in the genus are actually devoid of punctations and that their absence is not due to the condition of preservation since the structure can always be detected to some extent, at least, in all the undoubted Spiriferinas, whatever their condition of preservation, but in these shells it has never been detected.

Delthyris clarksvillensis (Winchell)

Plate XXXVI, Figs. 6-7

1865. *Spiriferina Clarksvillensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 119.
1894. *Spiriferina clarkesvillensis* Keyes, Mo. Geol. Surv., vol. 5, p. 85.
1908. *Spiriferina clarksvillensis* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 83, pl. 18, figs. 10-12.

Description.—Shell below medium size, wider than long, hinge-line as long as, or a little shorter than, the greatest width of the shell, the cardinal extremities angular or a little rounded. The dimensions of a nearly complete but somewhat distorted specimen are: length of pedicle valve 11 mm., length of brachial valve 9.1 mm., width 16.8 mm., thickness ±8 mm., width of sinus in front 5.4 mm., height of cardinal area 3.9 mm.

Pedicle valve moderately convex, most prominent on the umbo, but little or not at all compressed towards the cardinal extremities, the surface curving rather abruptly to the cardinal margin on each side of the beak, more gently to the anterior margin and most gently to the lateral margins; mesial sinus rather wide, of moderate depth, non-plicate, and rounded in the bottom; beak only moderately incurved; cardinal area of moderate height, nearly flat below, becoming concave towards the beak, the lateral margins sharply defined or rounding slightly into the surface of the lateral slopes; the delthyrium of moderate size, higher than wide; each lateral slope marked by from four to seven, rather broad, rounded, plications which originate along the cardinal margin. Internally a median septum is present which reaches between one-third and one-half the length of the shell from the beak, the remaining internal characters not observed.

1 Synop. Am. Foss. Brach., Bull. 87, U. S. Geol. Survey, p. 206. (1897.)

Brachial valve less convex than the pedicle, the greatest convexity near the middle, compressed towards the cardinal extremities; the mesial fold rounded, but little elevated above the general surface of the valve; cardinal area very narrow, lying in nearly the plane of the valve; plications similar to those of the opposite valve and alternate with them. Internal characters not observed.

Besides the plications the surface of each valve is ornamented by conspicuous, somewhat irregular, lamellose, imbricating, concentric markings, about two or three occupying the space of one millimeter.

Remarks.—In none of the specimens of this species, which have been examined by the writer, has the punctate shell structure of the genus *Spiriferina* been observed. In the original description of the species, however, it is stated "internal surface of the valve marked with numerous indented punctations," and this would seem to indicate that the species possesses this characteristic structure of the genus *Spiriferina*. Not infrequently in undoubted species of *Spiriferina*, this structure is obscure and cannot be detected upon many examples, but an examination of a sufficient number of specimens usually leads to its recognition. This species differs from most of the other members of the genus here described, also from members of the genus *Spiriferina*, in its stronger and coarser concentric lamellæ. The number of plications is a somewhat variable character, but they are always coarser and less numerous than usual in the genus. The species which most closely resembles this one is *D. missouriensis*, and the differences between the two forms will be considered under the discussion of that species.

Horizon.—Louisiana limestone.

Delthyris missouriensis Weller

Plate XXXVI, Figs. 9-14

1906. *Delthyris missouriensis* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 445, pl. 6, figs. 23-26.

Description.—Shell small, wider than long, the greatest width usually a little in front of the hinge-line, and the cardinal extremities narrowly rounded. The dimensions of a pedicle valve are: length from umbo to front margin 10 mm., width 12.5 mm., length of hinge-line 11 mm., convexity 4.5 mm., height of cardinal area 2.2 mm. The dimensions of a large brachial valve are: length 9 mm., width 13.4 mm., convexity 3 mm.

Pedicle valve rather strongly convex, the convexity extending out to the cardinal extremities, the umbo prominent, the surface curving rather abruptly to the anterior margin and sloping in nearly straight lines to the cardinal extremities; mesial sinus originating at the beak, of moderate width, rather shallow, and rounded or somewhat flattened in the bottom; the beak rather obtuse, a little incurved; cardinal area of moderate

height, only slightly concave, the lateral margins angular and well-defined; the delthyrium narrowly triangular, higher than wide; each lateral slope bearing three or four simple, rounded plications which originate near the cardinal margin. Internally the valve bears a distinct median septum.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface a little compressed towards the cardinal extremities; mesial fold rounded, but little elevated above the general surface of the valve; the plications similar to those of the opposite valve and alternate with them.

Besides the plications the surface of each valve is ornamented by strong, crowded, sublamellose, concentric markings, three or four of which occupy the space of one millimeter.

Remarks.—This species most closely resembles *D. clarksvillensis,* agreeing with that species in its rather shallow, rounded sinus and low fold, in the rather coarse rounded plications, and in the stronger and coarser concentric lamellose markings of the shell than is usual in other species. *D. missouriensis* differs from *D. clarksvillensis* in its somewhat narrower shell and more convex pedicle valve, and in the smaller number of plications. The specimens whose dimensions have been given are among the largest ones observed, a great number of individuals having a width of less than 5 mm.

Formation.—Glen Park limestone and Hamburg oolite of the Kinderhook.

Delthyris suborbicularis Weller

Plate XXXVI, Fig. 8

1906. *Delthyris suborbicularis* Weller, Trans. St. Louis Acad. Sci., vol. 16 p. 446, pl. 6, figs. 27-28.

Description.—Shell small, broader than long, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of a pedicle valve are: length 10.5 mm., width 11.7 mm., length of hinge-line 8.7 mm., convexity 3 mm., height of cardinal area 2.3 mm.

Pedicle valve moderately convex, the convexity extending out to the cardinal extremities, the surface sloping with a gently convex curvature from the umbo to the anterior and lateral margins; mesial sinus originating at the beak, rather broad and shallow, rounded in the bottom; the beak obtuse, scarcely incurved; cardinal area slightly concave, sloping posteriorly from the hinge-line and lying at an angle of about 130 degrees to the plane of the valve, the lateral margins not sharply defined, the surface rounding into that of the lateral slopes of the valve; delthyrium higher than wide; each lateral slope bearing five or six simple, low, rounded plications which originate near the cardinal margin and grow

successively smaller towards the cardinal extremities. Internally a strong median septum reaches from the beak to a point between one-third and one-half the length of the valve, the dental plates diverge anteriorly from the beak and reach anteriorly less than one-half the length of the median septum.

Brachial valve not known.

Surface of the shell ornamented by rather strong, regular, sublamellose, concentric markings, about three or four of which occupy the space of one millimeter.

Remarks.—The species differs from its associate, *S. missouriensis*, in the less strongly convex pedicle valve, in the nearly flat cardinal area with its posteriorly sloping position, in the more obtuse beak of the pedicle valve, and in the greater number of plications.

Horizon.—Glen Park limestone of the Kinderhook.

Delthyris novamexicana (Miller)

Plate XXXVI, Figs. 15-24

1881. *Spirifera novamexicana* Miller, Jour. Cinn. Soc. Nat. Hist., vol. 4, p. 314, pl. 7, figs 10-10b.
1909. *Spiriferina magnicostatus* Weller, Bull. Geol. Soc. Am., vol. 20, p. 307, pl. 13, figs. 12-15.

Description.—Shell small, much broader than long, the greatest width along the hinge-line, the cardinal extremities often produced into slender, mucronate extensions. The dimensions of a somewhat imperfect and distorted specimen, more than usually extended along the hinge-line, are: length of pedicle valve +7 mm., length of brachial valve 6 mm., width along hinge-line 24 mm., thickness ±6 mm.

Pedicle valve most prominent in the umbonal region, becoming compressed towards the cardinal extremities; the mesial sinus of moderate depth, rounded in the bottom, bounded laterally by a pair of strong, rounded ribs which originate at the beak and which are prominently elevated above the plications on either side; the beak rather small, pointed and incurved; the cardinal area low, concave, with its lateral margins sharply defined; the delthyrium about as wide as high; lateral slopes convex from the cardinal to the anterior margins, the slope from the umbo to the cardinal extremities concave, each one marked by three or sometimes four clearly defined, rounded plications, beyond those which bound the mesial sinus, they originate along the cardinal margin, and decrease gradually in size towards the cardinal extremities, and on shells greatly extended along the hinge-line one or more additional, extremely faint plications may sometimes be detected; the largest of the lateral plications are distinctly smaller than those which bound the mesial sinus. Internally, the umbonal portion of the valve is solidified,

at least in mature shells, the muscular scar is strongly defined and is divided longitudinally by an angular ridge which becomes more septum-like towards the beak, and which in young examples with less completely solidified beaks, perhaps became a distinct median septum; the dental plates are short, scarcely more than ridge-like thickenings of the shell along the inner borders of the delthyrium.

Brachial valve less convex than the pedicle, greatest convexity near or posterior to the middle, compressed towards the cardinal extremities; mesial fold but little elevated above the general surface of the valve, rounded or flattened on top, sometimes with a faint mesial line which is scarcely a depressed furrow; the plications of the lateral slopes similar to those of the opposite valve and alternate with them, the furrows bounding the mesial fold somewhat deeper and broader than those between the other plications.

In addition to the plications the surface of each valve is ornamented by strong, regular, sublamellose, imbricating, concentric markings, four or five of which occupy the space of one millimeter, and which are fimbriate along their margins.

Remarks.—This species is characterized by the great breadth of the shell, its mucronate cardinal extremities, and the strong plications bounding the sinus of the pedicle valve. The punctate structure which these shells should exhibit if they belong to the genus *Spiriferina* has not been observed, and consequently the species is referred to the genus *Delthyris*. Perhaps a more important deviation from the typical structure of *Spiriferina* is the absence of a true median septum in the pedicle valve. There is along the median line of the muscular scar a distinct, broadly angular median ridge, but it can scarcely be interpreted as a median septum in the mature condition of the shell at least. It may have been such in the younger stages of growth, before the apical portion of the valve became so solidified as it is in the mature specimens, but the interior of such young examples has not been observed.

Horizon.—Fern Glen formation.

Delthyris similis n. sp.

Plate XXXVI, Figs. 49-53

Description.—Shell small, much wider than long, the greatest width along the hinge-line, the cardinal extremities subrectangular, the lateral and anterior margins regularly rounded or the anterior margin somewhat truncated in the middle. The dimensions of a nearly complete internal cast in chert are: length of pedicle valve 14 mm., length of brachial valve 10 mm., width 19 mm., thickness 12 mm., height of cardinal area 4 mm., width of mesial sinus in front 6.6 mm.

Pedicle valve strongly convex, the surface sloping with a gently convex curvature from the umbonal region to the cardinal extremities, and curving more abruptly to the anterior margin; mesial sinus originating at the beak, sharply defined, rounded in the bottom, becoming rather deep anteriorly and produced in a rounded, lingual extension in front, of greater or less length; beak moderately incurved, remote from that of the opposite valve; cardinal area high, concave, with the concavity increasing towards the beak, the lateral margins sharply defined, sloping from the beak to the cardinal extremities with an increasingly convex curvature distally, the delthyrium higher than wide. Surface of valve marked by strong, simple, rounded or subangular plications which originate at the beak or along the cardinal margin, the mesial sinus is marked by a single faint plication along its median line which may be entirely obsolete in the internal casts; each lateral slope marked by from six to eight plications which become successively fainter towards the cardinal extremities; concentric lines of growth mark the valve which not infrequently become rather strong towards the margin. Internally the dental lamellæ are well developed and sometimes extend anteriorly for one-fourth the length of the valve from the beak, following the lines of the first intercostal furrows each side of the sinus; between the dental lamellæ is a strong median septum which extends farther anteriorly than the dental lamellæ, sometimes nearly to the middle of the valve.

Brachial valve somewhat less convex than the pedicle, its greatest convexity near or in front of the middle, the surface curving more abruptly to the cardinal margin towards the beak, usually a little depressed towards the cardinal extremities; the mesial fold well defined by furrows which are wider and deeper than those between the plications, becoming rather highly elevated towards the front, flattened on top with a median furrow which is more conspicuous than the median rib of the sinus of the opposite valve; beak small, moderately incurved. Surface marked by plications similar in number and form to those of the opposite valve, and by similar concentric lines of growth. Internally a slight median ridge extends anteriorly from the beak to near the middle of the valve.

Remarks.—In general form and size this species resembles *Cyrtina neogenes,* and the two shells have sometimes been confused. In the condition of internal casts in chert, the only condition in which either of these species have been certainly recognized, *D. similis* can always be recognized by the presence of three distinct slits diverging anteriorly from the beak of the pedicle valve, representing the dental lamellæ and the median septum, while in *C. neogenes* a single median slit is present. The plications of *D. similis,* also, are usually somewhat more subangular than those of *C. neogenes,* and by this character the brachial valves of the two

species may be differentiated. In none of the casts of this species which have been examined, has any punctate structure of the shell been observed, but this shell structure is almost without exception well shown upon the casts of *C. neogenes* by the fine papillæ which are the casts of the original perforations of the shell. The fine surface markings have not been observed in this species because of the lack of proper external impressions of the shell, such as have been seen of *C. neogenes*. The species was clearly well marked by concentric growth lines, but it is not known that they were such strongly lamellose and regular markings as are characteristic of many species of *Delthyris*. It is believed that this was their character, a character which, in the absence of a punctate shell structure, would throw the species into the genus *Delthyris* rather than *Spiriferina*.

Horizon.—Residual chert, probably of Keokuk age.

Genus *SPIRIFER* Sowerby

Description.—Shells varying in size from small to very large, usually wider than long, rarely longer than wide, the hinge-line straight, shorter than the greatest width of the shell and the cardinal extremities rounded; or more frequently the greatest width of the shell along the hinge-line and the cardinal extremities angular and more or less extended, sometimes conspicuously acuminate. Mesial sinus in the pedicle valve and fold in the brachial valve usually well developed, more rarely without fold or sinus. Surface of both valves marked by radiating plications which may be simple without division from the point of origin at the cardinal margin to the anterior margin, or may divide in various manners; the plications may be present upon the lateral slopes only or upon both the lateral slopes and the fold and sinus. Besides the plications the surface may also be marked by fine, radiating striæ or by fine or coarse concentric growth lines, or by both radiating and concentric markings. The pedicle valve with the beak variously elevated above the hinge-line and variously incurved, the cardinal area varying from very narrow to high, usually arched but sometimes nearly or quite flat, the delthyrium rather broadly triangular and open; the surface of the cardinal area is transversely striate and the inner shell layers bear a series of vertical canals at whose extremities along the hinge-line the shell tissue is sometimes produced in a row of denticles which articulate with a row of pits in the opposite valve. Internally the hinge-teeth are strong and are supported by short dental lamellæ; the muscular area is of moderate size and is often deeply impressed, ovate or obcordate in outline, occupied in large part by the diductor scars which are usually marked by radiating or branching furrows. The brachial valve with a very narrow cardinal area divided by a broadly triangular delthyrium; the cardinal process is a low, transverse, sessile apophysis with its surface

vertically striated; the muscular impressions much less strongly marked than in the pedicle valve; the dental sockets narrow and of moderate depth, the socket plates well developed and at their extremities supporting the crural bases; the crura are long, straight, and slightly divergent, the spiral cones are directed obliquely outward and posteriorly towards the cardinal extremities, the primary lamellæ are not united by a jugum, but the position of the jugum is indicated by the presence of a pair of spine-like processes upon the primary lamellæ a little in front of their junction with the crura.

Remarks.—This genus has the largest specific representation of any in our Mississippian faunas, and the species themselves are usually very characteristic of the horizon in which they occur. As a whole the Mississippian species are characterized by the presence of plications in the fold and sinus of the valves, and in a large number of the species the plications upon the lateral slopes exhibit more or less bifurcation.

Spirifer marionensis Shumard

Plate XXXVII, Figs. 1-7

1855. *Spirifer Marionensis* Shumard, Geol. Rep. Mo., 1855, p. 203, pl. C, figs. 8a-b (not fig. 8c).
1858. *Spirifer marionensis* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 511, pl. 6, figs. 1a-c.
1883. *Spirifera Marionensis* Hall, 2nd Ann. Rep. N. Y. State Geol., pl. (31) 56, fig. 15.
1894. *Spirifer Marionensis* Hall and Clarke, 13th Ann. Rep. N. Y. State Geol., vol. 2, pl. 27, fig. 3.
1894. *Spirifera marionensis* Keyes, Mo. Geol. Surv., vol. 5, p. 78, pl. 40, figs. 1a-b.
1895. *Spirifer Marionensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 31, fig. 15.
1908. *Spirifer marionensis* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 81, pl. 18, figs. 1-5; p. 88, pl. 19, figs. 3-6.

Description.—Shell of medium size, subsemicircular to subtriangular in outline, greatest width usually along the hinge-line, cardinal extremities acutely angular in immature shells, the hinge-line becoming relatively shorter and the cardinal extremities more obtuse with age. The dimensions of an average specimen are: length of pedicle valve 24 mm., length of brachial valve 20 mm., width along hinge-line 39 mm., thickness 17 mm., height of cardinal area 3 mm.

Pedicle valve moderately convex, usually becoming compressed towards the cardinal extremities, the umbonal region rather narrow, the surface curving abruptly from it to the cardinal margin for a short distance on each side of the beak, the slope more gentle to the antero-lateral margins; beak small, pointed, and incurved; cardinal area of moderate height, arched, the curvature increasing towards the beak, the lateral margins

sharply defined, subparallel with the cardinal margin through nearly the entire length of the area, the lateral extremities of the area abruptly truncate, its surface both longitudinally and vertically striate; lateral slopes of the valve convex towards the middle, often with an obscure oblique sinuosity extending from the side of the umbonal region to just in front of the cardinal extremities, each marked by about 20 rounded plications, the first two or three of which adjacent to the sinus usually bifurcate in passing to the anterior margin, the other plications remaining simple; mesial sinus originating at the beak where it is sharply defined, becoming less sharply defined anteriorly, it is shallow and rounded in the bottom, a median plication originates near the beak and passes without division to the anterior margin, on each side there are usually two lateral plications originating from the inner margins of the bounding plications, all the plications of the sinus being similar in form and size to those of the lateral slopes.

Brachial valve slightly less convex than the pedicle, with a narrow, linear cardinal area, the greatest convexity of the valve near or posterior to the middle; mesial fold originating at the beak where it is bounded by furrows deeper than those between the other plications of the shell, not at all or but little elevated above the general surface of the shell in the umbonal region, and but slightly elevated anteriorly, it is rounded in contour and is marked by plications similar in form and number to those of the mesial sinus of the other valve, all of which originate through the division of a single plication at the beak; lateral slopes moderately convex antero-posteriorly, the curvature more abrupt towards the cardinal margin, the surface somewhat compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings consist of fine concentric striæ which are crowded at intervals to form more or less conspicuous, irregularly arranged lines of growth which are often crowded towards the anterior margin.

Remarks.—This species resembles several other Kinderhook members of the genus *Spirifer*, but it may always be distinguished by the form of the cardinal area of the pedicle valve, the two margins of the area being essentially parallel almost to their very extremities, giving to the area the form of a long, narrow parallelogram, while in the allied species the lateral margins of the area slope laterally towards the hinge-line, giving to the area a broadly triangular outline. From *S. vernonensis*, the species may also be distinguished by its less convex valves and less prominent fold and sinus.

The manner of growth which produces the characteristic form of cardinal area of this species is peculiar. In the younger growth stages of the shell the hinge-line is much extended into mucronate points, so that when

the shell has reached one-third of its mature size the hinge-line has reached nearly its maximum length, with a very narrow cardinal area. During the more mature growth of the shell the length of the hinge-line remains stationary, while the shell itself increases in length and the cardinal area increases in height. In rare instances the elongation of the hinge-line is retarded still earlier in the life of the individual so that as the shell increases in size the greatest width is not along the hinge-line, but is in front of this line and the cardinal extremities become rounded in the mature shell.

This species is especially characteristic of the fauna of the Louisiana limestone. In the original description of the species it was said to occur also in the Chouteau limestone of central Missouri, and it has been frequently identified by later authors from various Kinderhook localities and horizons. All of these identifications, however, are believed to be incorrect. Aside from in the Louisiana limestone, the species has been recognized by the writer only in the yellow Kinderhook sandstone at Kinderhook, Illinois. The specimens from this locality are all imperfect and more or less poorly preserved. They seem to attain a somewhat larger size than the Louisiana limestone specimens, and in none of them has the form of the cardinal area been actually observed. The sandstone specimens exhibit the shallow sinus and low fold of the typical members of the species, and the lines of growth seem to indicate the early attainment of the maximum length of the hinge-line during the growth of the shell, and for these reasons the specimens are provisionally referred to this species.

Horizon.—Louisiana limestone.

Spirifer vernonensis Swallow

Plate XXXVII, Figs. 8-17

1860. *Spirifer vernonensis,* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 644.
1865. *Spirifer Vernonensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 119.
1909. *Spirifer vernonensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 302, pl. 13, figs. 3-8.

Description.—Shell of medium size, subsemicircular in outline, wider than long, the greatest width along the hinge-line, cardinal extremities angular. The dimensions of two individuals are: length of pedicle valve 23 mm. and 25 mm., length of brachial valve 17.5 mm. and 20.5 mm., width 31 mm. and 43 mm., thickness 19 mm. and 22 mm., height of cardinal area 3.5 mm. and 3.5 mm.

Pedicle valve strongly convex, strongly arched from the beak to the front, the median line often describing nearly a semicircle; beak small, pointed, strongly incurved; cardinal area of moderate height, arched,

the enrvature becoming stronger towards the beak, the lateral margins sharply defined, sloping from the beak to the cardinal extremities with a convex curve which becomes more abrupt as it approaches the end, the surface marked by vertical striæ and by fine longitudinal lines of growth, hinge-line finely crenulate; lateral slopes convex throughout the greater portion of their area, becoming more or less compressed towards the cardinal extremities, often with a slight sinuosity passing obliquely from the side of the umbo to just in front of the cardinal extremity, each marked by from 15 to 18 subangular or rounded, mostly simple, but rarely bifurcating plications which grow progressively smaller towards the cardinal extremities; mesial sinus sharply defined at the beak and losing but little of its definition anteriorly, it is rather deep and subangular or rounded in the bottom, with a conspicuous lingual prolongation in front, it is marked by a median plication which originates near the beak and continues without division to the anterior margin, each side is marked by three or four lateral plications which originate successively from the inner margins of the lateral bounding plications.

Brachial valve nearly as convex as the pedicle, most elevated at or near the anterior extremity of the mesial fold, with a narrow, linear cardinal area; mesial fold sharply defined to the beak by a pair of furrows deeper than those between the other plications, depressed and but slightly elevated above the general surface of the valve posteriorly, becoming strongly elevated and sometimes slightly recurved towards the anterior margin, simple at the beak but marked anteriorly by 8 or 10 plications which originate through the successive bifurcation of the original median ridge; lateral slopes convex towards the center of the shell, the curvature more abrupt to the cardinal margin, becoming somewhat compressed towards the cardinal extremities.

The entire surface of the shell is marked by fine, concentric, sublamellose lines which are crowded at intervals, especially towards the front, to form more or less conspicuous lines of growth.

Remarks.—This species resembles *S. marionensis*, but it is much more convex in both valves, with a much more elevated mesial fold and depressed sinus anteriorly. The shape of the cardinal area of the pedicle valve is also different, the lateral margins sloping laterally towards the cardinal extremities, while in *S. marionensis* the two margins of the area are essentially parallel. The manner of growth of the shell of this species is accountable for the difference in the form of the cardinal area from that of *S. marionensis*. The length of the hinge-line continues to increase throughout the entire period of growth of the shell, although as the shell approaches maturity, the elongation is proportionally less rapid; at the same time the height of the cardinal area is continually increasing so that the mature shell possesses the broadly subtriangular cardinal area.

Horizon.—Fern Glen formation.

Spirifer pikensis Rowley

Plate XXXVIII, Figs. 1-5

1902. *Spirifer pikensis* Rowley, Am. Geol., vol. 29, p. 309, pl. 18, figs. 17-22.

Description.—Shell large, broader than long, the hinge-line a little shorter than the greatest width, the cardinal extremities obtusely angular. The dimensions of a nearly perfect specimen, the holotype, are: length of pedicle valve 62 mm., length of brachial valve 53.4 mm., greatest width 80.5 mm., thickness 36 mm., length of hinge-line 70 mm., height of cardinal area 5 mm.

Pedicle valve moderately convex, the surface curving abruptly from the umbonal region to the cardinal margin on each side of the beak, and sloping with a gently convex curve to the lateral and antero-lateral margins, only slightly compressed towards the cardinal extremities; mesial sinus originating at the beak where it is narrow, angular and rather sharply defined, less well defined anteriorly where it is narrowly rounded in the bottom and rapidly increases in depth, becoming profound towards the anterior margin, greatly produced in front in a conspicuous lingual extension which is narrowly rounded at its extremity; the beak rather small and pointed, moderately incurved at the apex; cardinal area rather low, gently concave except just under the beak, where the curvature becomes much stronger, the lateral margins sharply defined and sloping with a gentle curvature from the beak to the cardinal extremities, the delthyrium rather small, broader than high. Surface of the valve marked by rounded, radiating plications which occupy the lateral slopes and the mesial sinus, the largest plications occur upon the lateral slopes adjacent to the sinus where they sometimes measure 3 mm. from center to center at the front margin, towards the cardinal extremities they gradually decrease in size, about 25 being present upon each lateral slope, about 16 occupy the sinus, all the larger plications bifurcate once or sometimes twice near the beak, with an occasional bifurcation further towards the front, sometimes in front of the middle of the valve.

Brachial valve more convex than the pedicle, its greatest depth at the front of the mesial fold, surface of the valve sloping posteriorly from the point of greatest convexity along the median line in nearly a straight line for about two-thirds the length of the valve, from which point it is convexly curved to the beak; from the median line the surface curves abruptly on either side anteriorly, to the lateral borders of the mesial fold, beyond which lines the surface is gently convex, becoming somewhat compressed towards the cardinal extremities, curving more abruptly to the cardinal margin on either side of the beak; mesial fold only slightly elevated near the beak, but rapidly becoming highly elevated in the anterior half of the valve where it is narrowly rounded across the top; beak small and rather strongly incurved, the umbonal region

only slightly protuberant beyond the hinge-line. Surface marked by plications similar in form and number to those of the opposite valve, those of the mesial fold becoming much broader and less elevated towards the front than those of the lateral slopes.

A few rather faint lines of growth are present upon each valve, the finer surface markings not preserved upon the type specimen.

Remarks.—This species is especially characterized by the extreme development of the fold and sinus near the front of the shell, no other species being present in our faunas which is at all comparable in this respect. Another distinguishing character is to be found in the bifurcation of the plications and their unusual width towards the front.

Horizon.—Burlington limestone.

Spirifer shepardi n. sp.

Plate XXXVIII, Figs. 6-8

Description.—Shell of medium size, subsemicircular in outline, the greatest width along the hinge-line, the cardinal extremities angular, sometimes mucronate. The dimensions of a nearly perfect pedicle valve are: length 21 mm., width along hinge-line 40.5 mm., convexity 12.5 mm., height of cardinal area 5 mm. The dimensions of a somewhat imperfect brachial valve are: length 20 mm., approximate width 36 mm., convexity 7 mm.

Pedicle valve rather strongly convex, greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the antero-lateral margins, usually a little compressed towards the cardinal extremities, sometimes with an ill-defined sinuosity passing obliquely from each side of the beak to the lateral margins just in front of the cardinal extremities; beak small, pointed, incurved; cardinal area of moderate height, arched, the curvature increasing towards the beak, lateral margins sharply defined, sloping from the beak to the cardinal extremities; lateral slopes marked by from 20 to 23 rounded plications, the first two or three on each side of the fold and sinus may bifurcate, the others simple, towards the cardinal extremities the plications become successively weaker, the last two or three being sometimes very faint or obsolete; mesial sinus of moderate depth, rounded or subangular in the bottom, sharply defined to the beak, somewhat loosing its definition anteriorly, but slightly produced in front, marked by a median plication which originates near the beak and passes to the anterior margin either without division or bifurcating, on each side there are from two to four plications which originate from the inner margins of the lateral bounding plications or through the bifurcation of plications so originating, making usually from 7 to 9 plications in all.

Brachial valve depressed convex, usually much less convex than the pedicle valve, the greatest convexity near or posterior to the middle, the surface somewhat compressed towards the cardinal extremities; mesial fold depressed, usually not elevated above the general surface of the valve posteriorly and but slightly elevated anteriorly, bounded by a pair of furrows somewhat deeper and stronger than those between the plications, marked by plications similar in form and number to those of the sinus of the opposite valve, all of which originate through the division of a single one at the beak; lateral slopes convex towards the middle of the valve, the curvature more abrupt towards the cardinal margin, compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

Surface of both valves marked by fine, concentric, subimbricating lines which are crowded at intervals to form lines of growth of greater or less strength.

Remarks.—This species has sometimes been identified as *S. marionensis,* but it is quite different from that species, being more closely allied to *S. vernonensis.* It differs from *S. vernonensis,* however, in being marked by more numerous and finer plications, those upon the fold and sinus being equally prominent with those upon the lateral slopes, in not having the sinus of the pedicle valve produced anteriorly and consequently lacking the strongly elevated fold of the brachial valve. It differs from *S. osagensis* in its larger size, its more numerous and sometimes bifurcating plications upon the lateral slopes, and in the larger number of plications upon the fold and sinus. The species is in some respects intermediate in character between *S. vernonensis* and *S. osagensis.*

Horizon.—Pierson limestone of the Kinderhook.

Spirifer osagensis Swallow

Plate XXXVII, Figs. 18-21

1860. *Spirifer osagensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 641.
1899. *Spirifer marionensis* Weller, Trans. St. Louis Acad. Sci., vol. 9, p. 17, pl. 4, fig. 12.

Description.—Shell of medium size or smaller, subsemicircular or subsemielliptical in outline, the greatest width along the hinge-line, the cardinal extremities mucronate. The dimensions of two rather small but nearly complete individuals with the mucronate cardinal extremities destroyed are: length of pedicle valve 16.5 mm. and 15.5 mm., length of brachial valve 15.3 mm. and 14.8 mm., width, exclusive of cardinal extremities, 22 mm. and 19.5 mm., thickness 13 mm. and 12.5 mm., height of cardinal area 2.5 mm. and 2.3 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the umbonal region prominent, the surface curving abruptly

to the cardinal margin on each side of the beak, to the antero-lateral margins the curvature is more gentle, an ill-defined oblique sinuosity passes from the cardinal margin on each side of the beak to just in front of the cardinal extremities, the valve sometimes a little compressed towards the cardinal extremities; beak rather small, pointed, incurved; cardinal area rather low, arched, the curvature becoming greater towards the beak, lateral margins sharply defined, sloping from the beak to the cardinal extremities in a nearly straight line or with a gently convex curve, surface of the area vertically striate; lateral slopes convex towards the mesial sinus, usually slightly compressed towards the cardinal extremities, marked by from 13 to 15 simple, rounded plications which grow successively smaller towards the cardinal extremities, the last two or three sometimes being very faint or almost obsolete; mesial sinus originating at the beak where it is sharply defined, becoming less sharply defined anteriorly, it is rather shallow and rounded or subangular in the bottom, marked by a median plication which originates near the beak and passes without division to the anterior margin, on each side are from 1 to 3, but mostly 2, lateral plications which originate from the inner margins of the lateral bounding plications.

Brachial valve a little less convex than the pedicle, the greatest convexity near or posterior to the middle; mesial fold sharply defined to the beak, the bounding furrows deeper and stronger than those between the other plications, but little or not at all elevated in the posterior half of the shell, becoming slightly elevated anteriorly; it is marked anteriorly by plications similar in form and number to those of the sinus of the opposite valve, all of which originate through the division of a single plication at the beak; lateral slopes convex towards the middle of the valve, becoming compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings are obscure in all of the specimens examined because of the condition of preservation, but concentric markings of the shell are clearly indicated which are sometimes crowded into more or less conspicuous lines of growth.

Remarks.—This species has sometimes been identified as *S. marionensis*, but it differs markedly from that species in the shape of the cardinal area and also in the absence of bifurcating plications upon the lateral slopes. From *S. vernonensis* it differs in the less strongly convex valves, in the shallower sinus, and in the absence of the conspicuous lingual extension in front, and in the lower mesial fold, also in the mucronate extensions of the hinge-line. These mucronate extensions are frequently missing on the specimens as they occur in the form of more or less imperfect casts, but in every specimen in which this portion of the shell is uninjured, they have been observed, and it is believed that the character

is a constant one. The younger individuals of *S. marionensis* possess similar mucronate cardinal extremities, but the hinge-line does not continue to increase in length through the entire life of the individual as it does in *S. osagensis*.

The shell illustrated by Meek from the Ohio Waverly as *S. biplicatus*[1] resembles this one very closely in general form and size and may be identical, it is certainly entirely different from the true *S. biplicatus*. Well preserved examples of this shell from Licking County, Ohio, preserve the minute, surface characters perfectly, which consist of fine, exceedingly regular, concentric marks, which are crossed by still finer radiating striæ, giving the surface a very beautiful reticulate appearance. None of the Missouri examples of *S. osagensis* are preserved so as to show such markings, but if they should be present the identity of the Ohio shells is more sure.

Horizon.—Kinderhook.

Spirifer latior Swallow

Plate XXXVIII, Figs. 9-13

1863. *Spirifer latior* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 86.

Description.—Shell small, subsemicircular in outline, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly perfect specimen are: length of pedicle valve 12.5 mm., length of brachial valve 10 mm., width along hinge-line 15.5 mm., thickness 9 mm., height of cardinal area 2.5 mm.

Pedicle valve rather strongly convex with the greatest convexity posterior to the middle and well towards the umbo, the surface curving abruptly to the cardinal margin, the slopes from the umbo to the cardinal extremities at first gently convex, becoming a little concave towards the cardinal extremities, to the anterior and antero-lateral margins the curvature is gently convex; beak small, pointed and incurved; cardinal area of moderate height, concave, the lateral margins sharply defined and sloping from the sides of the beak to the cardinal extremities; mesial sinus originating at the beak as a narrow, sharply defined groove-like depression becoming broader and ill-defined anteriorly where it is rather shallow and rounded in the bottom, a rounded median plication originates in the umbonal region and continues to the front without subdivision, upon each side of the median one there is a single similar plication which originates from the inner margin of the bounding plications of the sinus; each lateral slope of the valve marked by 12 to 15 simple, rounded plications which decrease regularly in size towards the cardinal extremities.

1 *Spirifer biplicatus* ? Meek, Pal. Ohio, vol. 2, p. 290, pl. 14, fig. 5 (1875).

Brachial valve less convex than the pedicle, the greatest depth a little posterior to the middle, becoming a little compressed towards the cardinal extremities; cardinal area very narrow and linear; mesial fold originating at the beak, where it is bounded by rather strong furrows but is not elevated above the surface of the valve on either side, anteriorly it continues to be sharply defined by the stronger furrows but is conspicuously depressed to the front, being scarcely elevated above the surface of the lateral slopes, it is marked by four subequal, rounded plications, all of which originate through the subdivision of the original one at the beak; each lateral slope marked by simple plications which are entirely similar in form and number to those of the opposite valve.

The minute surface markings are not well preserved upon the specimens observed, but the concentric lines of growth are inconspicuous, commonly being restricted to a few faint ones near the margin of the shell.

Remarks.—The original type of this species was never illustrated and the specimen itself has been lost, and from the original definition alone it would be difficult to determine the status of the species. In the collection of Mr. D. K. Greger, however, a specimen is preserved accompanied by a label written by Swallow himself. This specimen is considered to be authentic and it agrees in all essential respects with the original definition. The specimen which is illustrated herewith, and which has been used in the preparation of the above description, agrees in all essential respects with the authentic example in the Greger collection. The species is a small one, although it grows considerably larger than the specimen whose dimensions have been given, and is characterized especially by its rotund form, there being little or no compression of the pedicle valve towards the cardinal extremities, and the mesial fold of the brachial valve being depressed to such a degree that it scarcely interrupts the general convexity of that valve. The species is evidently not a common form.

Horizon.—Chouteau limestone.

Spirifer platynotus n. sp.

Plate XXXIX, Figs. 1-10

1901. *Spirifer marionensis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 188, pl. 16, figs. 16-17.

Description.—Shell below medium size, subsemicircular to broadly sub-triangular in outline, greatest width along the hinge-line, cardinal extremities more or less acutely angular. The dimensions of two pedicle valves are: length 16 mm. and 15.5 mm., width along the hinge-line 25 mm. and ±42 mm., convexity 8 mm. and 7.5 mm., height of cardinal area 3.5 mm. and 3.5 mm. The dimensions of a brachial valve are: length 16 mm., width along the hinge-line ±38 mm., convexity 6.5 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin on each side of the beak, curving more gently to the antero-lateral margins and becoming compressed towards the cardinal extremities; beak small, pointed, moderately incurved; cardinal area of moderate height, arched, the curvature slight in the inferior portion, becoming stronger towards the beak, lateral margins sharply defined, sloping from the beak to the cardinal extremities, the slope becoming more abrupt distally, surface marked by vertical lines, the hinge-margin minutely crenulate, the delthyrium large, broadly triangular; lateral slopes convex towards the middle of the valve, becoming compressed towards the cardinal extremities, each marked by from 16 to 20 depressed rounded plications which grow successively fainter towards the cardinal extremities, in those individuals with excessively elongate hinge-lines becoming nearly or quite obsolete distally, the first one or two plications on each side of the sinus bifurcate close to the beak, the remaining ones are simple; mesial sinus shallow, rounded in the bottom, defined to the beak, becoming less sharply defined anteriorly, marked by a median plication which originates near the beak and passes to the anterior margin either as a simple plication or bifurcating near the middle of the valve, on each side are one, or more rarely two, plications which originate from the inner margin of the bounding plications.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface curving more abruptly to the cardinal margin, compressed towards the cardinal extremities; mesial fold defined from the beak to the front by a pair of furrows which are deeper and stronger than those between the plications, scarcely or not at all elevated above the general surface of the valve through its entire extent, marked by four or five plications similar to those on the lateral slopes which originate from a single one at the beak; lateral slopes marked by plications similar in form and number to those of the opposite valve.

The minute surface markings consist of exceedingly fine concentric striæ which are sometimes crowded at intervals, and especially towards the anterior margin, to form more or less conspicuous lines of growth.

Remarks.—This species is especially characterized by the great variation it exhibits in the length of the hinge-line, and in the complete, or almost complete, lack of elevation of the mesial fold of the brachial valve above the general surface of the valve. The pedicle valve often more or less closely resembles that of *S. osagensis,* but the plications are finer and more numerous, and the hinge-line is apt to be more elongate, the brachial valves of the two species are less alike.

The types of this species are all from the white oolitic bed, No. 6 of the Kinderhook section at Burlington, Iowa, but some specimens in the yellow sandstone bed, No. 5, just below, and in the superjacent bed, No. 7,

seem to represent the same species. The specimens from both these horizons seem to be more uniformly elongate along the hinge-line, and none of those observed attain so large a size as is common among the examples from the oolite.

Horizon.—Kinderhook.

Spirifer missouriensis Swallow

Plate XXXIX, Figs. 11-23

1860. *Spirifer Missouriensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 643.

Description.—Shell of medium size or smaller, wider than long, the greatest width along the hinge-line, cardinal extremities angular, the plications of the fold and sinus similar to those of the lateral slopes. The dimensions of two individuals are: length of pedicle valve 22.5 mm. and 21 mm., length of brachial valve 18 mm. and 17 mm., width ±38 mm. and 31 mm., thickness 18 mm. and 14 mm., height of cardinal area 3.5 mm. and 3.2 mm.

Pedicle valve more or less strongly convex, the greatest convexity posterior to the middle, the surface curving more or less abruptly from the umbonal region to the cardinal margin on each side of the beak, more gently to the antero-lateral margins, compressed towards the cardinal extremities; beak small, pointed, incurved; cardinal area of moderate height, arched, the curvature increasing towards the beak, lateral margins sharply defined, sloping from the beak to the cardinal extremities; lateral slopes convex towards the center of the valve, more or less compressed towards the cardinal extremities, each marked by from 18 to 20 subangular plications along the antero-lateral margin which originate from 10 to 13 plications starting at the beak or along the cardinal margin; from 3 to 5 of the original plications on each side of the beak divide into 2 or 3 in, or a little in front of, the umbonal region and continue in more or less distinct fascicles to the anterior margin, the furrows between these groups of plications being stronger and deeper than those between the members of the group; mesial sinus sharply defined at the beak, becoming less well defined anteriorly, it is subangular or rounded in the bottom, of moderate depth and sometimes somewhat produced anteriorly into a nasute or lingual extension, it is marked by a median plication which originates near the beak and bifurcates in passing to the anterior margin; on each side there are from 3 to 5 plications which originate from the inner margins of the lateral bounding plications or through the bifurcation of such plications.

Brachial valve equally or a little less convex than the pedicle, the greatest convexity usually near the middle; mesial sinus sharply defined towards the beak by a pair of deeper and stronger furrows than those between the other plications, becoming somewhat less sharply defined ante-

riorly, it is subangular or rounded in contour and sometimes becomes quite strongly elevated in front, marked by bifurcating plications to the number of from 8 to 12 at the anterior margin, all of which originate from a single one at the beak; lateral slopes most convex in the umbonal region, the curvature more abrupt to the cardinal margin, compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are usually more or less completely lacking in the specimens, but a few examples retain fine radiating striæ which doubtless originally covered the entire shell surface, and also still finer concentric striæ. Concentric lines of growth are more or less strongly marked upon some examples.

Remarks.—This species is characteristic of the Chouteau limestone. It may be easily recognized by the more or less distinct fasciculate arrangement of the plications, in which respect it is similar to *S. cameratus* of the Pennsylvanian faunas. *S. cameratus*, however, attains a much larger size and in it the fasciculate arrangement of the plications is carried to a greater extreme.

Horizon.—Chouteau limestone.

Spirifer biplicatus Hall

Plate XXXIX, Figs. 24-26

1858. *Spirifer biplicatus* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 519, pl. 7, fig. 5b (not fig. 5a).
1900. *Spirifer biplicatus* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 77, pl. 2, figs. 6-7.

Description.—Shell small, much wider than long, subtriangular in outline, with the apex of the triangle truncated at the anterior margin, cardinal extremities produced into extremely elongate, mucronate points. The dimensions of the internal cast of a pedicle valve are: length 9 mm., width along the hinge-line 50 mm., convexity 5 mm. The dimensions of a brachial valve are: length 8.5 mm., width along the hinge-line, estimated, 42 mm., convexity 4 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the umbo rather prominent, the surface of the valve compressed laterally; beak small, incurved; cardinal area narrow, lateral margins not sharply defined in the internal cast, the only condition in which the species has been observed, but probably sharply defined in the original condition; lateral slopes convex antero-posteriorly, the curvature more abrupt to the cardinal margin, compressed towards the cardinal extremities, each marked by about 12 simple, rounded plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities; mesial sinus narrow and shallow, bounded by a

pair of broad plications which are much stronger than any others on the valve, marked by a single median plication which originates in the umbonal region and continues without division to the anterior margin.

Brachial valve a little less convex than the pedicle, the greatest convexity near the middle; mesial fold narrow, sharply defined by a pair of furrows deeper and wider than those between the plications, but little elevated above the general surface of the valve, divided by a median furrow originating in the umbonal region which is weaker than those between the plications; lateral slopes convex antero-posteriorly, curving more abruptly to the cardinal margin, the surface compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

None of the specimens observed are in a proper condition of preservation to show the finer markings of the shell, although they consisted of concentric lines. More or less distinct concentric lines of growth are sometimes recognizable upon the casts.

Remarks.—With his original definition of the species *S. biplicatus,* Hall illustrated two brachial valves, one of which is from the Chonopectus sandstone at Burlington, Iowa, the other from the higher yellow sandstone of the Kinderhook section at the same locality.[1] A large number of specimens have been studied in connection with the present investigation and they seem clearly to be representatives of two distinct species. The name *S. biplicatus* is restricted to the form from the Chonopectus sandstone which seems to correspond more closely with the definition of the species, the other form being here named *S. biplicoides.* The *S. biplicatus* is characterized by the distinctly biplicate fold and sinus, while *S. biplicoides* has an additional lateral plication upon each lateral slope of the fold and sinus in the full grown shells. The cardinal extremities of *S. biplicatus* are also much more extended into slender points than in *S. biplicoides,* the length of the extensions, when complete, being equal to one-half the distance along the hinge-line from a point beneath the beak to the extreme end of the hinge-line. The length of the body of the shell is proportionately less in *S. biplicatus* and the number of plications as seen in the casts is usually smaller, although this last character would perhaps not distinguish the two forms if the shell itself were preserved.

Horizon.—Chonopectus sandstone of the Kinderhook.

[1] The specimen from the higher yellow sandstone is erroneously stated by Hall to be from the oolitic limestone bed of the Kinderhook section at Burlington, but the specimen itself is preserved in the American Museum of Natural History in New York, and is clearly from the upper Yellow sandstone.

Spirifer louisianensis Rowley

Plate XL, Figs. 1-23

1900. *Spirifer louisianensis* Rowley, Am. Geol., vol. 25, p. 262, pl. 5, figs. 18-20, 64.

Description.—Shell small, subtriangular to subsemicircular or subsemielliptical in outline, wider than long, the greatest width along the hinge-line, the cardinal extremities more or less acutely angular. The dimensions of two examples from the type locality are: length of pedicle valve 11.9 mm. and 10 mm., length of brachial valve 10.8 mm. and 8.9 mm., width along hinge-line 13.6 mm. and 13.2 mm., thickness 10 mm. and 8.4 mm., height of cardinal area 2.4 mm. and 2.2 mm., width of mesial sinus in front 4 mm. and 3 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle and well back on the umbonal region, the umbo prominent and narrow, the surface curving abruptly to the cardinal margin on each side of the beak and rather steeply to the antero-lateral margins; beak small, pointed and incurved; cardinal area of moderate height, arched, the curvature becoming greater towards the beak, broadly triangular in outline, its lateral margins sharply defined, sloping from the beak to the cardinal extremities with a gently convex curve which becomes more abrupt distally; lateral slopes convex antero-posteriorly, the posterior slope to the cardinal margin more abrupt, the slope from the umbo to the cardinal extremities nearly straight or slightly convex, each lateral slope marked by 10 to 13, usually simple, rounded, radiating plications, the first one or two on each side of the sinus sometimes bifurcating close up to the beak; mesial sinus narrow, shallow, rounded in the bottom, sharply defined by angular plications at the beak, sometimes losing more or less of its definition anteriorly, marked by a median plication which originates near the beak and continues without division to the anterior margin, on each side are one, or more rarely two,plications which originate from the inner margin of the bounding plications.

Brachial valve less convex than the pedicle, with a narrow, linear cardinal area; mesial fold scarcely elevated above the general surface of the valve except towards the front, bounded by a pair of furrows which are broader and deeper than the other furrows of the valve, marked by from 2 to 5 plications, all of which originate from a single one at the beak; lateral slopes most convex towards the mesial fold, the surface curving more abruptly to the cardinal margin, becoming more or less compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

Surface of shell, when well preserved, marked by exceedingly fine, regular, concentric striæ, about 15 of which occupy the space of 1 mm. and

by slightly coarser radiating striæ which are more conspicuous in the furrows between the plications than upon the plications themselves.

Remarks.—This species may be easily recognized by its deep pedicle valve, its narrow umbonal region, and narrow fold and sinus. The minute surface markings have been observed only upon specimens from the white cherts at Louisiana, Missouri.

Horizon.—Upper Kinderhook and lower Burlington limestone.

Spirifer biplicoides n. sp.

Plate XXXIX, Figs. 27-30

1858. *Spirifer biplicatus* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 519, pl. 7, fig. 5a (not fig. 5b).

1901. *Spirifer centronatus* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 163, pl. 14, figs. 3-4.

Description.—Shell small, much broader than long, the greatest width along the hinge-line, the cardinal extremities acuminate. The dimensions of a pedicle valve are: length 11 mm., width along the hinge-line 32 mm., convexity 5.5 mm. The dimensions of a brachial valve are: length 8 mm., width along the hinge-line 25 mm., convexity 3.5 mm.

Pedicle valve strongly convex from beak to front, the greatest convexity near or posterior to the middle of the shell, the surface compressed towards the cardinal extremities which are produced into more or less elongate, attenuate points; beak small, pointed, incurved; cardinal area narrow, arched, the lateral margins sharply defined, sloping from the beak to the cardinal extremities; lateral slopes convex antero-posteriorly, becoming compressed distally, each marked by from 12 to 16 simple, rounded plications; mesial sinus narrow and shallow, defined to the beak, the bounding plications much broader than any of the plications of the lateral slopes, marked by a low and narrow median plication which originates in the umbonal region and continues without division to the anterior margin, a little in front of the point of origin of the median plication each of the broad, bounding plications is divided by a narrow groove much weaker than those between the plications of the lateral slopes, the inner division of the plication occupying the lateral slopes of the sinus.

Brachial valve less convex than the pedicle, the greatest convexity near or posterior to the middle, compressed towards the cardinal extremities; mesial sinus sharply defined by a pair of furrows which are distinctly broader and stronger than those between the other plications, it is depressed and not elevated above the general surface of the valve posteriorly and is but slightly elevated anteriorly, it is simple at the beak, is divided by a median furrow in the umbonal region and further towards the front in mature shells each of the lateral divisions is again subdivided, all the furrows of the fold being weaker than those which separate the plications

upon the lateral slopes of the shell; lateral slopes of the valve depressed convex, marked by plications similar in form and number to those of the opposite valve.

The finer surface markings of the shell have only been observed upon squeezes taken from natural moulds which do not perfectly preserve their character. They consist, so far as can be seen, of fine, concentric, sublamellose lines of growth which are more or less crowded at intervals, especially towards the front of the shell.

Remarks.—This species has only been observed in the condition of detached and more or less incomplete separate valves, and in this condition it is not always easy to distinguish between it and *S. platynotus*, with which it is sometimes associated. It does not attain so large a size as *S. platynotus*, it does not exhibit so great variation in the lateral extension of the hinge-line, being uniformly more extended than that species and with the angular cardinal extremities more acuminate, the lateral bounding plications of the sinus of the pedicle valve are conspicuously broader and more differentiated from the other plications of the valve, the sinus itself is narrow and has but one lateral plication on each side which is less sharply differentiated from the bounding plication than from the median one. The fold of the brachial valve in the two species is similar in being little or not at all elevated above the general surface, but it is more sharply differentiated in *S. biplicoides*.

The species differs from *S. louisianensis* in its proportionately broader shell, more extended cardinal extremities, shallower pedicle valve with broader umbonal region and lower cardinal area. The bounding plications of the mesial sinus of the pedicle valve are also broader and more differentiated in this species than in *S. louisianensis*.

Members of this species were originally included by Hall under his species *S. biplicatus*, indeed, of the two specimens figured as the types of that species, one is an example of *S. biplicoides*. The distinctions between the two species are pointed out under the discussion of *S. biplicatus*, but besides being different in character, the two forms occur at different geologic horizons within the Kinderhook.

Horizon.—Kinderhook.

Spirifer insculptus Rowley

Plate XL, Figs. 30-34; Plate XLI, Figs. 1-5

1900. *Spirifer insculptus* Rowley, Am. Geol., vol. 25, p. 268, pl. 5, figs. 1-3.

Description.—Shell above medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly perfect specimen, the holotype, are: length of pedicle valve 24 mm., length of brachial valve 20 mm., width along hinge-

line +60 mm., thickness 23.5 mm., height of cardinal area 11.5 mm. The dimensions of another specimen, less extended along the hinge-line are: length of pedicle valve 24 mm., length of brachial valve 19 mm., width along hinge-line 38.5 mm., thickness 20 mm., height of cardinal area 10 mm.

Pedicle valve subpyramidal in form, the surface sloping from the umbonal region to the antero-lateral and anterior margins with a very gently convex curve, the slope becoming nearly straight beyond the middle of the valve, curving somewhat more abruptly to the cardinal margin for a short distance on either side of the beak, becoming slightly compressed subparallel with the cardinal area towards the cardinal extremities; mesial sinus well defined, originating at the beak where it is narrow and shallow, becoming rapidly broader and attaining a moderate depth towards the front, nearly flat across the bottom in front with gently sloping sides; beak small, rather obtusely pointed, a little incurved; cardinal area high, the inferior portion nearly flat and lying in an angle of about 90 degrees or a little less to the plane of the valve, the higher portion of the area concave with the curvature increasing to the beak, the lateral margins sharply defined and sloping in nearly straight or slightly convex lines from the beak to the cardinal extremities. Surface of valve marked by rounded, radiating plications, which occupy both the sinus and the lateral slopes, the larger of which measure about 2 mm. from center to center, from 12 to 17 are present upon each lateral slope, all of which are simple and originate along the cardinal margin, growing successively smaller towards the cardinal extremities, the plications of the sinus are about six in number, the median one originates in the umbonal portion of the valve and continues to the front margin without division, the lateral ones all originate as offshoots from the inner sides of the lateral bounding plications of the sinus and continue to the front without division and essentially parallel with the median one.

Brachial valve moderately convex with the curvature more abrupt to the cardinal margin, becoming a little compressed towards the cardinal extremities; mesial fold well defined, flat on top, sloping abruptly to its lateral margins on the sides anteriorly, of only moderate height, becoming rapidly broader towards the front; the beak small and obtuse, only slightly protuberant beyond the cardinal margin, and slightly incurved. Surface marked by plications entirely similar to those of the opposite valve in form and number, all those of the fold originate through the bifurcation of the original simple plication at the beak and then through the division of these two main branches from their inner margins, all the plications continuing to the front in a nearly parallel direction.

Surface of both valves, in addition to the plications, marked by very regular, somewhat crowded, subimbricating, concentric markings, and by occasional stronger lines of growth.

Remarks.—This species may be easily recognized by its high cardinal area, its extended hinge-line, and especially by its broad, flattened fold and sinus whose plications are essentially parallel with the median line of the shell.

Horizon.—Lower Burlington limestone.

Spirifer legrandensis n. sp.

Plate XL, Figs. 24-29

Description.—Shell below medium size, broadly subtriangular in outline, the width more than twice the length, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly perfect individual are: length of pedicle valve from beak to front 17.5 mm., length of brachial valve 14.5 mm., width along hinge-line 36 mm., thickness 15.5 mm., height of cardinal area 7 mm.

Pedicle valve broadly subpyramidal in form, the greatest depth nearly opposite the hinge-line; beak small, sharply pointed, moderately incurved over the area; cardinal area high, broadly subtriangular in outline, the inferior portion nearly flat and making an angle of about 90 degrees to the plane of the valve, becoming concave towards the beak, lateral margins sharply defined, sloping regularly from the beak nearly to the cardinal extremities beyond which point the slope becomes more abrupt, delthyrium higher than wide; lateral slopes gently convex, the curvature most abrupt to the cardinal margin near the beak, each marked by from 16 to 18 simple, subangular plications which become successively smaller towards the cardinal extremities; mesial sinus shallow, sharply defined from beak to front by angular plications, marked by a median plication which originates near the beak and becomes strong and angular towards the front, in the larger individuals each side of the sinus is marked by a single plication much weaker than the median one, which originates from the inner margins of the lateral bounding plications.

Brachial valve much shallower than the pedicle, with a narrow, linear cardinal area; mesial fold low, flattened on top, sharply defined to the beak where it is simple, in the umbonal region the single plication is divided into two by a median furrow corresponding to the median plication of the opposite valve, each side being again divided in the larger examples between the umbo and the front of the shell; lateral slopes convex antero-posteriorly, the surface curving much more abruptly to the cardinal margin, each marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are not preserved in any of the specimens observed, but several concentric lines of growth are present which are more crowded towards the front of the shell.

Remarks.—This species has sometimes been identified as *S. biplicatus*,

an identification which has doubtless been made because of the strong median plication of the sinus; the two species, however, are totally different, *S. legrandensis* having a high cardinal area, while *S. biplicatus* has a low one, and the cardinal extremities are never extended into the extremely attenuated points in *S. legrandensis* as they are in *S. biplicatus*. There is no species of *Spirifer* in any of our Mississippian faunas which can be compared with this one. It resembles, however, *S. macbridei* Calvin, from the Upper Devonian fauna at Rockford, Iowa, but it is proportionally much broader, with a more nearly flat cardinal area, and has a larger number of plications. It also resembles *S. bimesialis* Hall, also from the Upper Devonian of Iowa, but it attains a larger size with a somewhat higher area and more incurved beak, and in the mature shell it often has a pair of lateral plications in the sinus in addition to the strong median one.

Horizon.—Kinderhook.

Spirifer subæqualis Hall

Plate XLIII, Figs. 1-10

1858. *Spirifer subæqualis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 663, pl. 23, figs. 9a-c.
1883. *Spirifer subæqualis* Hall, Rep. N. Y. State Geol. for 1882, pl. (31) 56, figs. 13-14.
1894. *Spirifer subæqualis* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 27, fig. 2.
1895. *Spirifer subæqualis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 31, figs. 13-14.
1906. *Spirifer subæqualis* Beede, 30th Ann. Rep. Geol. Survey Ind., p. 1316, pl. 21, figs. 3-3b.

Description.—Shell above medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly perfect individual are: length of pedicle valve 29.8 mm., length of brachial valve 23.5 mm., greatest width, along the hinge-line 60 mm., thickness 23 mm., height of cardinal area 5.5 mm.

Pedicle valve most convex posterior to the middle, the surface sloping with a gently convex curvature from the umbonal region nearly to the cardinal extremities where it becomes a little compressed, to the cardinal margin the surface slopes with a short and rather abrupt curvature, especially near the beak, the slope to the anterior and antero-lateral margins long and regularly curved; beak small, pointed and moderately incurved; mesial sinus shallow, rounded in the bottom, of moderate width, ill-defined laterally; cardinal area concave, becoming more curved towards the beak, the lower and more flattened portion lying at an angle of about 65 degrees to the plane of the valve, the lateral margins sharply defined and sloping with a gently convex curvature from the beak to the cardinal extremities, the surface marked by vertical striæ. Surface of

the valve marked by about 75 or 80 flattened, radiating plications at the margin, those in the central portion of the valve, in the sinus and for some distance on either side, increase by bifurcation near the beak or more rarely between the beak and the middle of the valve, from 16 to 20 plications occupying the sinus in front with about 30 upon each lateral slope; rather fine, crowded, subimbricating concentric markings cross the radiating plications, usually being more conspicuous towards the front margin, in addition to which are occasional much stronger concentric lines of growth.

Brachial valve less convex than the pedicle, its greatest convexity near the middle, the surface convex antero-posteriorly, but gently concave from the median region in the long slope to the cardinal extremities, the curvature to the cardinal margin shorter and more abrupt than that to the anterior margin; mesial fold originating at the beak where it is rather sharply defined by deeper furrows, but scarcely elevated above the general surface of the valve, anteriorly it is rounded, becoming ill-defined, and is essentially undifferentiated from the lateral slopes of the valve; the beak incurved, the umbonal region but little protuberant beyond the cardinal margin; the cardinal area narrow, with sharply defined margin. Surface marked by radiating plications and concentric lines entirely similar to those of the opposite valve.

Remarks.—This species seems to be a rather rare form and has sometimes been confused with *S. tenuicostatus.* It differs from that species in having rather coarser and much less angular plications, and less conspicuous, sublamellose, concentric markings. The number of plications in the specimen mentioned above is fully equal to the number usually recognized in examples of *S. tenuicostatus,* but it a broader specimen than is often found in the other species and consequently the plications themselves are somewhat wider, about 8 or 9 in the space of 10 mm., in the median portion of the front margin, while *S. tenuicostatus* usually has about 10 to 12 in the same space. The species has much the form and proportions of *S. forbesi,* but that species is commonly somewhat more extended along the hinge-line and has coarser and less commonly bifurcating plications. In *S. tenuicostatus* the plications bifurcate more frequently towards the front.

Horizon.—Keokuk limestone and Warsaw formation.

Spirifer tenuicostatus Hall

Plate XLII, Figs. 4-16

1858. *Spirifer tenuicostatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 662, pl. 23, figs. 8a-c.

1906. *Spirifer subæqualis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1316, pl. 20, figs. 4-4b.

Description.—Shell of medium size, wider than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly complete specimen, one of the cotypes, are: length of pedicle valve 27.5 mm., length of brachial valve 24.8 mm., width 41 mm., thickness 17.5 mm., height of cardinal area 5 mm. The dimensions of another one of the cotypes, a pedicle valve, are: length 25 mm., greatest width 41 mm., height of cardinal area 7 mm.

Pedicle valve most convex posterior to the middle, the surface sloping rather abruptly from the umbonal region to the cardinal margin, much more gently to the antero-lateral margins, somewhat compressed towards the cardinal extremities; beak small, pointed and moderately incurved; cardinal area arched, becoming more curved towards the beak, its lateral margins sharply defined and sloping gently from the beak to the cardinal extremities, the surface marked by vertical striæ; lateral slopes of the valve each bearing 28 to 34 narrow, rounded plications, some of which bifurcate; mesial sinus rounded in the bottom, originating at the beak where it is sharply defined, becoming more or less ill-defined anteriorly, it is marked by from 10 to 14 plications similar to those upon the lateral slopes of the valve, the median plication originates near the beak and continues to the front margin either as a simple rib or bifurcating, the lateral plications originate from the inner margins of the two bounding plications or through the bifurcation of plications so originating.

Brachial valve less convex than the pedicle, its greatest convexity near the middle; mesial fold originating at the beak, it is narrow and scarcely elevated in the umbonal region but becomes moderately elevated anteriorly where it is ill-defined and rounded or subangular in contour, it is marked by from 10 to 14 plications similar to those of the opposite valve which originate from a single plication at the beak; lateral slopes moderately convex towards the middle of the valve, somewhat compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell consist of fine, more or less irregular, raised, concentric lines. Both valves are also marked by numerous, imbricating, sublamellose lines of growth, which are crowded near the front of most shells.

Remarks.—This species has frequently been identified as *S. subæqualis*, but a critical examination of many individuals, including the cotypes, has shown that these two species are not synonymous. *S. tenuicostatus* has somewhat finer and more angular plications, and also much more conspicuous sublamellose concentric markings.

The species is sometimes associated with *S. lateralis*, and in a crushed and imperfect condition there may be some difficulty in distinguishing between them, but *S. lateralis* has more acutely angular cardinal extremities with a carinate median fold, and does not possess the conspicuous con-

centric lamellose lines of growth which are so characteristic of *S. tenuicostatus.*

Horizon.—Keokuk limestone, Warsaw formation and Salem limestone.

Spirifer lateralis Hall

Plate XLIII, Figs. 11-15

1858. *Spirifer lateralis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 661, pl. 23, figs. 7a-e.

1901. *Spirifer lateralis* var. *delicatus* Rowley, Greene's Cont. to Ind. Pal., vol. 1, p. 68, pl. 23, figs. 21-23.

1906. *Spirifer lateralis delicatus* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1314, pl. 20, figs. 3-3a.

Description.—Shell of medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a complete example, the holotype of the species, are: length 20.5 mm., width 51 mm., thickness 16 mm., height of cardinal area 4 mm.

Pedicle valve with its greatest convexity near the middle, the umbonal region broad and rather compressed, the surface curving strongly from the beak to the anterior margin and very gently in a lateral direction, becoming a little compressed towards the cardinal extremities; beak compressed, obtusely pointed, incurved; cardinal area arched, the curvature becoming greater towards the beak, the inferior portion directed posteriorly nearly in the plane of the valve, the lateral margins very sharply defined, sloping with a gently convex curve from the beak to the cardinal extremities; lateral slopes each marked by 25 or more fine, rounded, simple plications, most of which terminate posteriorly along the cardinal margin, towards the cardinal extremities the plications become faint and almost obsolete; mesial sinus originating in the umbonal region, in the posterior half of the valve it is shallow and ill-defined, anteriorly it becomes deeper but is still ill-defined, at the anterior margin it is produced in a tongue-like extension, it is marked by plications which are similar in size to those upon the lateral slopes but which increase by division in passing from the beak to the anterior margin, about 15 being present in front.

Brachial valve subequally convex with the pedicle, the greatest convexity near the front margin; mesial fold not sharply defined, strongly elevated and carinate posteriorly, becoming more rounded towards the front, posteriorly where the fold is carinate along the median line of the valve, the sides of the fold are concave and curve gradually into the lateral slopes of the valve, anteriorly the sides become convex, the fold is occupied by about 16 rounded plications which originate through the division of probably a single one at the beak; lateral slopes of the valve

strongly convex from the cardinal to the anterior margins, somewhat compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are not preserved on the specimens observed, but several concentric lines of growth of variable strength are usually present, becoming stronger and more frequent towards the anterior margin in mature shells.

Remarks.—This species is especially characterized by the strongly carinate mesial fold of the brachial valve, and when that portion of the shell is preserved it is always easy of identification. In its surface characters, especially the size and character of the plications, the species resembles *S. tenuicostatus*, and worn, fragmentary examples of the two species are sometimes indistinguishable. *S. lateralis*, however, does not possess the bifurcating plications nor the conspicuous lamellose, concentric markings of *S. tenuicostatus*, and the character of the fold and sinus, as well as the general form and proportions of the valves, are totally different in the two species, *S. lateralis* being proportionally shorter with more sharply angular cardinal extremities.

The specimen which has been illustrated as *S. lateralis* by Hall and Clarke,[1] is clearly not a member of this species, it has more the aspect of an undersized example of *S. logani*, although the depth of the sinus seems to be too great for an individual of that species of such a size. The shell which Rowley has described as *S. lateralis* var. *delicatus* is scarcely worthy of varietal designation, it being only a depauperate individual in the Spergen Hill fauna of Indiana, where many species are represented by specimens smaller than the more usual form of the same species elsewhere.

Horizon.—Warsaw formation and Salem limestone.

Spirifer forbesi Norwood and Pratten

Plate XLII, Figs. 1-3; Plate XLIII, Fig. 16; Plate LXXXIII, Figs. 1-2

1855. *Spirifer Forbesii* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., (2), vol. 2, p. 73, pl. 9, figs. 3a-c.
1858. *Spirifer forbesi* Hall, Geol. Iowa, vol. 1, pt. 2, p. 600, pl. 13, fig. 1.
1894. *Spirifera forbesi* Keyes, Mo. Geol. Surv., vol. 5, p. 80, pl. 40, fig. 3.
1895. *Spirifer Forbesi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 37, fig. 18.

Description.—Shell above medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a pedicle valve of usual size are: length 24 mm., width along the hinge-line 54 mm., height of cardinal area 5 mm., depth 10 mm. The dimensions of a larger individual with the valves in articulation are: length of pedicle valve 27.3 mm., length of brachial valve

[1] Pal. N. Y., vol. 8, pt. 2, pl. 32, figs. 1-3. (1894).

24.3 mm., greatest width along the hinge-line 73 mm., thickness 24.5 mm., height of pedicle cardinal area 6.2 mm., height of brachial cardinal area 2 mm., width of sinus in front 12 mm.

Pedicle valve with its greatest depth posterior to the middle, the surface curving rather abruptly from the umbonal region to the cardinal margin on each side of the beak, the slope to the cardinal extremities nearly straight or slightly concave, that to the anterior margin gently convex, towards the cardinal extremities the surface is somewhat compressed in a direction subparallel to the cardinal area; mesial sinus rather narrow and more or less well defined, originating at the beak, usually shallow but sometimes of moderate depth, rounded in the bottom; the beak small, pointed, rather strongly incurved; the cardinal area of moderate height, concave with the curvature increasing towards the beak, the lateral margins sharply defined and subparallel with the hinge-line well out towards the cardinal extremities, the inferior flatter portion lying at an angle of about 120 degrees to the plane of the valve; the delthyrium large, broader than high. Each lateral slope marked by from 25 to 30 simple, depressed, rounded plications, separated by narrow, angular furrows, originating at or near the cardinal margin, those towards the cardinal extremities becoming very faint; the mesial sinus marked by a median plication originating in the umbonal region and by two or three lateral ones on each side which originate from the inner margins of the bounding plications.

Brachial valve subequally or less convex than the pedicle, its greatest depth posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the anterior margin, from the point of greatest depth to the cardinal extremities the slope is gently concave, the umbo slightly protuberant beyond the cardinal margin; the mesial fold is sharply defined, gently convex or flattened on top, originating at the beak and only moderately elevated above the general surface of the valve; a distinct cardinal area with sharply defined lateral margins subparallel with the hinge-line is present, it is gently concave and lies nearly in the plane of the valve; the beak small, strongly incurved. Each lateral slope marked by plications entirely similar in form and number to those of the opposite valve, the plications of the mesial fold also entirely similar to those of the sinus and all originating from the subdivision of the single plication at the point of origin.

Surface of both valves marked by fine, crowded, very regular, concentric, lamellose lines which are more closely crowded at intervals to form more or less conspicuous lines of growth.

Remarks.—This species is one of the less common Spirifers in the fauna of the Burlington limestone, the brachial valve especially being rare. It may be easily recognized by its elongate hinge-line and acute cardinal extremities. It differs from the associated *S. incertus,* which has similar

surfaee markings, in its greater width and more acute cardinal extremities. Of the specimens figured, the smaller pediele valve is the more typical. The larger speeimen with the valves in articulation has a much deeper mesial sinus than is usual, but in all other respects it is in full agreement with other representatives of the species.

Horizon.—Burlington limestone.

Spirifer mundulus Rowley

Plate XLIV, Figs. 15-19

1893. *Spirifera mundula* Rowley, Am. Geol., vol. 12, p. 307, pl. 14, figs. 10-12.

Description.—Shell small, very short and broad, the greatest width along the hinge-line, the eardinal extremities acutely pointed. The dimensions of a nearly perfeet specimen are: length of pediele valve 8 mm., length of brachial valve 6.2 mm., width along hinge-line 20.5 mm., thickness 7.3 mm., height of eardinal area 1.5 mm.

Pediele valve prominent in the umbonal region, the surfaee curving abruptly to the eardinal margin on either side of the beak, convex from the eardinal to the antero-lateral margins and sloping with a gently eoncave curvature laterally from the umbonal region to the eardinal extremities; mesial sinus originating at the beak where it is a mere groove, continuing to the front as a rather narrow and shallow depression, rounded in the bottom; beak prominent, pointed, and rather strongly ineurved; eardinal area of only moderate height, concave, the lateral margins sharply defined and subparallel with the hinge-line for the greater portion of their length. Surface of the valve marked by simple, low, rounded plications whieh originate along the eardinal margin and are confined to the lateral slopes, from seven to ten occupy eaeh lateral slope, of whieh those bounding the sinus are much the larger.

Brachial valve a little less eonvex than the pediele, the greatest eonvexity slightly posterior to the middle, the eurvature from the beak to the front along the median line nearly semicireular, the surfaee sloping from the point of greatest eonvexity to the eardinal extremities with a gently concave eurvature, rather strongly eonvex from the eardinal margin to the antero-lateral margins; mesial fold well-defined to the beak, rather narrow and only a little elevated above the general convexity of the valve, rounded on top with a very slight longitudinal median groove; beak small, obtuse, seareely projeeting beyond the eardinal margin. Surfaee marked by simple, radiating plications entirely similar to those of the opposite valve.

Surface of both valves marked by rather faint, concentric lines of growth which are somewhat crowded towards the front margin.

Remarks.—The general aspect of this little shell is more that of a *Spiriferina* than a *Spirifer*, but the shell shows no indications of having

been punctate, and it is not known to possess a median septum internally in the pedicle valve. Neither does it possess the strong, concentric, lamellose markings of the non-punctate *Delthyris*. Under these circumstances, then, the species may be allowed to remain in the genus *Spirifer* to which it was originally referred.

Horizon.—Lower Burlington limestone.

Spirifer imbrex Hall

Plate XLIII, Fig. 17

1858. *Spirifer imbrex* Hall, Geol. Iowa, vol. 1, pt. 2, p. 601, pl. 13, fig. 2.
1883. *Spirifera imbrex* Hall, Rep. N. Y. State Geol. for 1882, pl. (31) 56, figs. 11-12.
1894. *Spirifer imbrex* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 27, fig. 1.
1894. *Spirifera imbrex* Keyes, Mo. Geol. Surv., vol. 5, p. 80.
1895. *Spirifer imbrex* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 31, figs. 11-12.

Description.—Shell above medium size, much broader than long, the greatest width along the hinge-line. The dimensions of the holotype, a brachial valve, are: length 27 mm., greatest width 52 mm., depth 7 mm.

Brachial valve moderately convex, emarginate anteriorly in the holotype, greatest depth near the middle, the surface curving abruptly to the cardinal margin on either side of the beak, becoming compressed towards the cardinal extremities, with a gently convex curvature to the anterolateral margins; mesial fold sharply defined to the beak where it is narrow, gently convex and scarcely elevated above the lateral slopes, becoming more angular anteriorly but only moderately elevated; beak small, incurved. Surface of the valve marked by from 22 to 24 angular plications upon each lateral slope, and about 15 upon the mesial fold, the larger plications measuring about 2 mm. from center to center at the front of the shell, the plications of the lateral slopes frequently bifurcate once in passing from the cardinal margin to the front, all those of the fold originating from the subdivision of a single one at the beak. Crossing the plications, in the holotype, are two very strong concentric lines of growth anterior to the middle of the valve, and the entire surface is covered by fine concentric, sublamellose markings, about three of which occupy the space of 1 mm., and which are much more conspicuous anteriorly.

Remarks.—This species seems to be a rather unusual one in the Burlington limestone fauna, the specimens which have usually been so identified being examples of *S. incertus*. Good examples of the pedicle valve of the species have not been observed, in fact the holotype, which is a detached brachial valve, is the only really good example which has been studied. *S. imbrex* and *S. incertus* are similar in size and form, but *S. imbrex* is

characterized by its notably coarser and more angular plications. In the form of its plications and the finer concentric markings, *S. imbrex* resembles *S. vernonensis*, the larger and more transverse examples of *S. vernonensis* especially being suggestive of this species, but *S. vernonensis* has a more elevated mesial fold anteriorly than *S. imbrex*. and the mesial sinus is probably much deeper, the plications also are somewhat coarser.

Horizon.—Burlington limestone.

Spirifer incertus Hall

Plate XLI, Figs. 6-14

1858. *Spirifer incertus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 602, pl. 13, fig. 3.

Description.—Shell of medium size, about twice as wide as long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of two pedicle valves are: length 36 mm. and 28.5 mm., width 65 mm. and 55 mm., convexity 12 mm and 11 mm., height of cardinal area 5 mm. and 4 mm. The dimensions of a nearly complete specimen are: length of pedicle valve 31.5 mm., length of brachial valve 29 mm., width along hinge-line 56 mm., thickness 22.5 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the umbonal region broad, the surface sloping rather gently to the margins except to the cardinal margin for a short distance on each side of the beak; beak small, pointed, strongly incurved; cardinal area rather narrow, strongly arched, the superior portion from the beak well out towards the cardinal extremities being more strongly and abruptly curved, the inferior portion in adult examples directed at an angle of about 90 degrees to the plane of the valve, the lateral margins sharply defined, subparallel with the cardinal margins through a greater part of the length, sloping abruptly to the cardinal extremities distally, delthyrium large, broadly triangular; lateral slopes of the valve convex towards the median part of the valve, somewhat compressed towards the cardinal extremities, each bearing about 25 subangular or rounded plications at the margin, which originate through bifurcation from a much smaller number at the beak, the bifurcations mostly taking place in the umbonal region, only occasionally in the middle or anterior portion of the shell; mesial sinus narrow, simple and sharply defined at the beak, becoming ill-defined anteriorly where it is rather broad and of moderate depth, rounded or subangular in the bottom, marked by a median plication which originates near the beak and continues to the front margin without division, with 4 or sometimes 5 plications on each side which originate from the inner margin of the lateral bounding plication or through the bifurcation of plications originating in that manner, all the plications of the sinus are similar in form and size to those of the lateral slopes.

Brachial valve about as convex as the pedicle, the greatest convexity near the middle; the lateral slopes convex towards the middle part of the valve, the most abrupt curvature being towards the cardinal margin, becoming somewhat compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve; mesial fold defined by somewhat stronger furrows posteriorly but scarcely elevated above the general surface of the valve, anteriorly it becomes moderately elevated and is rounded or subangular along the median line and ill-defined laterally, it is marked by plications which are similar in form and number to those of the sinus of the opposite valve, all of which originate from a single plication at the beak.

The surface of both valves is marked by moderately fine, concentric, sublamellose lines which arch posteriorly as they cross the plications, and also by a few much stronger lines of growth which are usually stronger and more frequent towards the anterior margin.

Internally, as shown by casts of the interior preserved in chert, the dental lamellæ of the pedicle valve are short and diverge at an angle of about 60 degrees, the muscular impressions occupy a subovate area and are moderately impressed.

Remarks.—This is a rather common species in the fauna of the Burlington limestone which has commonly been confused with *S. imbrex*. The reason for this confusion is doubtless to be found in the imperfect specimen which was used by Hall as the type of the species, and the single unsatisfactory figure which accompanies the original definition. This type specimen is illustrated herewith, in three views, and, in addition, figures of more complete examples are given. The species differs from *S. imbrex* in having much finer and less angular plications.

Horizon.—Burlington limestone.

Spirifer carinatus Rowley

Plate XLVI, Figs. 13-17

1900. *Spirifer carinatus* Rowley, Am. Geol., vol. 25, p. 269, pl. 5, figs. 4-6.

Description.—Shell above medium size, wider than long, the hinge-line equaling or nearly equaling the greatest width, the cardinal extremities subrectangular. The dimensions of a nearly complete specimen with the brachial valve somewhat crushed, are: length of pedicle valve 34.5 mm., length of brachial valve 29 mm., greatest width 51.5 mm., thickness 23.5 mm., height of cardinal area 6 mm.

Pedicle valve with its greatest convexity near or posterior to the middle, the fullness of the valve extending well out towards the lateral margins, the surface curving abruptly to the cardinal margin on either side of the beak and a little more gently to the anterior margin, from the central portion of the valve to the lateral margins the curvature is at

first gently convex, but as it approaches the margins it becomes more curved and drops to the margin rather abruptly; mesial sinus originating at the beak where it is a slight, but well-defined groove, becoming less well-defined anteriorly, growing rapidly broader and deeper towards the front where it is very deep and subangular in the bottom, and is produced in a pointed lingual extension; the beak small, pointed, rather strongly incurved; the cardinal area of moderate height, the nearly flat or gently concave inferior portion sloping posteriorly at an angle of about 130 degrees to the plane of the valve, the higher portion more concave beneath the beak, the lateral margins sharply defined, sloping from the beak to the cardinal extremities in nearly straight lines most of the distance, becoming convexly curved distally, the delthyrium of moderate size, broader than long. Surface of the valve marked by rounded, bifurcating plications which occupy both the lateral slopes and the sinus, about 16 or 18 originate along the cardinal margin each side of the beak, about the first ten of which bifurcate before reaching the middle of the valve, so that from 26 to 28 are present upon each lateral slope at the margin of the valve, in the sinus a median plication originates in the umbonal region and continues to the front margin with one bifurcation near the middle of the valve, the lateral plications of the sinus originate from the inner margins of the bounding plications or from the bifurcation of such plications, from 12 to 15 being present at the front margin.

Brachial valve more convex than the pedicle, the greatest depth at the anterior margin, the surface curving rather abruptly to the cardinal margin on each side of the beak, curving more gently to the antero-lateral margins, compressed towards the cardinal extremities; the mesial fold defined to the beak, scarcely elevated above the general surface in the umbonal region, but becoming very greatly elevated in front where it becomes subcarinate along the median line, its lateral surfaces curving into the lateral slopes of the valve with only slight differentiation; beak small, incurved. Surface marked by bifurcating plications entirely similar in form and number to those of the opposite valve.

The surface of both valves marked by fine, regular, sublamellose, concentric markings, about three of which occupy the space of 1 mm., and by more conspicuous concentric lines of growth which become more frequent and more or less crowded anteriorly.

Remarks.—This species is a peculiar one and may be easily recognized by the extension of the convex fullness of the pedicle valve well out towards the cardinal extremities, in association with a compression of the brachial valve in the same direction. The strong elevation of the subcarinate fold of the brachial valve is another notable character of the species, as is also the character of the bifurcating plications of the shell. The species is perhaps most closely allied to *S. incertus*, which it resembles

in the fine, surface markings of the shell, but the less acutely angular, cardinal extremities, and the peculiar contour of the shell, indicated above, afford sufficient means of differentiating the two species.

Horizon.—Lower Burlington limestone.

Spirifer crawfordsvillensis n. sp.

Plate XLVII, Figs. 1-5

Description.—Shell of medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly complete example, the holotype of the species, are: length 23 mm., width 47 mm., thickness 13 mm., height of cardinal area 3 mm.

Pedicle valve only moderately convex in the central portion, becoming compressed towards the cardinal extremities, the umbonal region rather broad, the surface sloping abruptly from it to the cardinal margin for a short distance on each side of the beak, in other directions the slope is gentle; beak small, acuminate, pointed and incurved; cardinal area rather narrow, arched, the curvature becoming greater towards the beak, the lateral margins sharply defined, subparallel with the cardinal margin for some distance on each side of the beak, sloping to the cardinal extremities distally, surface of the area marked with vertical striæ and by longitudinal lines of growth; the lateral slopes of the valve each bearing 12 to 14 simple, rounded plications which grow successively smaller towards the cardinal extremities; mesial sinus originating at the beak, rounded in the bottom, becoming less well defined anteriorly, marked by plications similar to those on the lateral slopes of the valve except that they are somewhat smaller than those immediately adjacent to the sinus on each side; they consist of a median, simple one which probably originates near the beak, and of one or two lateral ones on each side which originate from the inner margins of the lateral bounding plications.

Brachial valve about equally convex with the pedicle, its greatest convexity near the middle; mesial fold originating at the beak, it is scarcely elevated above the general surface in the umbonal region, but becomes moderately elevated anteriorly where it is rounded in contour, it is marked by about 6 plications which are similar in size and form to those of the sinus of the opposite valve, all of which originate from a single plication at the beak; lateral slopes moderately convex, compressed towards the cardinal extremities, marked by plications which are similar in form and number to those of the opposite valve.

The minute surface markings consist of fine, crowded, concentric, lamellose lines. At intervals they are more closely crowded and give rise to more conspicuous lines of growth.

Remarks.—This species is a close ally of *S. forbesi* from the Burlington limestone. In general form, proportions and size the two species are essentially alike, but *S. crawfordsvillensis* is characterized by its coarser and less numerous plications upon the lateral slopes of the shell, these being only 12 or 14 in number, while in *S. forbesi* they exceed 20.

Horizon.—Keokuk (Crawfordsville beds of Indiana).

Spirifer washingtonensis n. sp.

Plate XLIV, Figs. 1-14

Description.—Shell of medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly complete individual are: length of pedicle valve 26.5 mm., length of brachial valve 20.5 mm., width 41 mm., thickness 17.5 mm., height of cardinal area 5.5 mm.

Pedicle valve moderately convex, the convexity reaching to the cardinal extremities or with the surface compressed distally, the umbonal region broad, the surface sloping abruptly to the cardinal margin and more gently to the antero-lateral margin; beak small, pointed, a little incurved; cardinal area of moderate height, nearly flat except just under the beak where it is arched, the inferior flattened portion extends posteriorly nearly in the plane of the valve, the lateral margins are sharply angular and slope with a gentle convex curve or in a straight line from the beak to the cardinal extremities; lateral slopes of the valve each bearing about 15 simple, rounded plications which grow successively smaller towards the cardinal extremities, the last 2 or 3 sometimes becoming very faint or obsolete: mesial sinus well defined at the beak, becoming broader and less well defined anteriorly, it is shallow or of moderate depth and is rounded in the bottom, a median plication originates near the beak and continues without division to the anterior margin where it is broad and strong, on each side is a single lateral plication which does not attain the strength of the median one, originating from the inner margins of the bounding plications.

Brachial valve subequally convex with the pedicle, the greatest convexity near the middle, mesial fold originating at the beak where it is bounded by furrows somewhat deeper than those between the plications, scarcely or not at all elevated above the general surface in the umbonal region, becoming moderately elevated in front, it is divided by a rather deep median groove corresponding with the median plication of the opposite valve, each lateral slope divided into two plications, all four of which join in a single plication at the beak; lateral slopes convex towards the middle of the valve, becoming somewhat compressed towards the cardinal extremities, marked by plications which are similar in form and number to those of the opposite valve.

The minute surface markings of all the specimens observed are nearly obliterated by the silicification of the shell, but at a few points very fine longitudinal striæ are preserved. It is not possible to determine whether or not the surface is also covered with fine, concentric markings of any sort. A few concentric lines of growth are present.

Remarks.—This species is quite distinct from any other members of the genus *Spirifer* in our Mississippian faunas. In its minute surface markings it seems to be like the large *S. grimesi* and *S. logani*, though this cannot be stated with certainty because of the poor preservation of these characters. In its general form the species is perhaps more nearly like some examples of *S. increbescens* than any other, but the valves are much less convex, the cardinal area is flatter and lies in a very different plane, and the strong median plication of the sinus is a characteristic feature.

Horizon.—Upper Keokuk limestone.

Spirifer pellaensis n. sp.

Plate XLV, Figs. 1-31

1858. *Spirifer keokuk* var. Hall, Geol. Iowa, vol. 1, pt. 2, p. 676, pl. 24, figs. 4a-d.
1883. *Spirifer keokuk* Hall, Rep. N. Y. State Geol. for 1882, pl. (30) 55, figs. 23-24 (not figs. 21-22).
1891. *Spirifer Rockymontana?* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 584, pl. 13, fig. 20.
1895. *Spirifera Rockymontana?* Whitfield, Geol. Surv. Ohio, vol. 7, p. 471, pl. 9, fig. 20.
1895. *Spirifer Keokuk* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 30, figs. 23-24 (not figs. 21-22).
1897. *Spirifer keokuk* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 257, pl. 18, figs. 10-12.
1911. *Spirifer keokuk* Morse, Proc. Ohio Acad. Sci., vol. 5, p. 377, fig. 11.

Description.—Shell below medium size, usually wider than long, but occasionally with the length and breadth nearly equal, greatest width at or in front of the hinge-line, the cardinal extremities rounded, rectangular, or more or less attenuate. The dimensions of a full grown example are: length 20.5 mm., greatest width along the hinge-line 26.5 mm., thickness 14.8 mm. The dimensions of another smaller and rounder example are: length 15 mm., greatest width near the middle of the shell 17 mm., length of hinge-line 13 mm., thickness 11.5 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the beak pointed and incurved; cardinal area concave, becoming more curved towards the beak, its height usually between 2 and 3 mm., the inferior portion sloping posteriorly at an angle of about 135 degrees to the plane of the valve, the lateral margins sharply defined and curving gently downward towards the cardinal extremities; lateral slopes of the valve convex, except towards the cardinal extremi-

ties where the surface is usually somewhat compressed, especially in those forms with an extended hinge-line, curving more abruptly to the cardinal margins than to the antero-lateral margins, surface of each lateral slope marked by from 9 to 13 simple, rounded plications which grow fainter towards the cardinal extremities, the most usual number being 10 or 11; mesial sinus originating at or near the beak, angular and sharply defined at first, becoming rounder and less sharply defined anteriorly where it is rather shallow or of moderate depth; near the beak a median plication originates in the sinus and continues without division, becoming gradually stronger to the anterior margin; on each side of the median plication there may be a single plication which is usually, but not always, weaker than the median one, which originates in the bifurcation of the lateral bounding plication of the sinus; occasionally a second plication is present on one or both sides which originates through a second bifurcation of the bounding plication nearer to the anterior margin.

Brachial valve a little less convex than the pedicle, the greatest convexity near the middle, the surface sloping more abruptly to the cardinal margin and becoming somewhat compressed towards the cardinal extremities; mesial fold sharply defined to the beak, at first scarcely, or not at all, elevated above the general surface, becoming gradually elevated anteriorly where it is rounded and of moderate height, it is marked by a median furrow to correspond with the median plication of the sinus, and usually with two plications on each side; lateral slopes marked by plications similar to those of the opposite valve in form and number.

The entire surface of both valves is marked by fine, concentric sublamellose markings which are more conspicuous anteriorly, and sometimes by occasional stronger lines of growth; also by exceedingly minute longitudinal striæ.

Remarks.—This species was originally described by Hall as a variety of *S. keokuk,* the specimens illustrated by him being from "the mouth of Lizard Creek, Webster County, Iowa." This locality is the site of the city of Fort Dodge at the present time, and has afforded the type specimens upon which the species has been established at this time. The species differs from *S. keokuk* in its smaller size, its more sharply defined and more angular mesial sinus towards the beak, and especially in the narrower and less gibbous umbonal region of the pedicle valve. The species is perhaps most closely allied to the more transverse variety of *S. increbescens,* from the Chester formations, but among these Chester specimens there is never so great variation exhibited in the length of the hinge-line, all of them being similar to the more transversely extended examples of *S. pellaensis.*

Horizon.—Pella beds of the Ste. Genevieve limestone.

Spirifer breckenridgensis n. sp.

Plate XLIV, Figs. 20-24

Description.—Shell below medium size, length and width sub-equal, or the length greater than the width, the hinge-line shorter than the greatest width, the cardinal extremities obtusely angular, the greatest width near the mid-length of the shell. The dimensions of two nearly complete individuals are: length of pedicle valve 20 mm. and 18 mm., length of brachial valve 15.5 mm. and 14.4 mm., greatest width 17.8 mm. and 18 mm., thickness 14 mm. and 13 mm., length of hinge-line 14.2 mm. and 13.4 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin with little or no compression towards the cardinal extremities, and more gently to the lateral margins, from the beak to the front margin the surface curves with regularly decreasing convexity; mesial sinus originating at the beak where it is very small but sharply defined, becoming rounder and somewhat less sharply defined anteriorly where it is of moderate depth, produced anteriorly in a rather short, rounded, lingual extension; the beak pointed and strongly incurved; the cardinal area of moderate height, concave, with the curvature increasing towards the beak, the flatter inferior portion sloping posteriorly at an angle of about 135 degrees to the plane of the valve, the lateral margins sharply defined, sloping from the beak to the cardinal extremities with a slightly sigmoidal curvature; the delthyrium rather large, its base occupying about one-fourth the length of the hinge-line. Surface of the valve marked by rounded plications, the largest of which are usually those bounding the mesial sinus; in the umbonal region of the mesial sinus a median plication originates as a faint rib which grows regularly larger anteriorly until it sometimes attains nearly the size of those bounding the sinus, upon each lateral surface of the sinus is a single somewhat smaller plication which originates in the umbonal region from the inner margin of the bounding plication; each lateral slope of the valve is marked by nine or ten simple plications which originate at or near the beak, these plications grow regularly smaller towards the cardinal extremities, the last one or two being very faint; the surface also marked by sublamellose, concentric lines of growth which become stronger and more crowded towards the front margin.

Brachial valve a little less convex than the pedicle, its greatest convexity near or a little posterior to the middle, the umbo a little prominent and produced slightly posteriorly beyond the hinge-line, the surface a little compressed towards the cardinal extremities, aside from which it is rather regularly convex; mesial fold originating at the beak as a median plication scarcely elevated above those on either side, becoming

moderately elevated in front and rather sharply differentiated from the lateral slopes of the valve; the beak short and a little incurved, the cardinal area distinctly developed but much narrower than that of the opposite valve, which it meets at an angle of about 90 degrees or a little less. Surface marked by plications entirely similar in form and number to those of the opposite valve, and by similar concentric markings.

Remarks.—This species has its nearest ally in *S. pellaensis*, from which it differs in its proportionately narrower and more elongate outline, and in always having the hinge-line shorter than the greatest width. An occasional specimen of *S. pellaensis* may approach very closely to this species in outline, and so seem to unite the two forms by intermediate variations, but the average form of *S. pellaensis* is much wider along the hinge-line than the average form of this species, a fact which is believed to be sufficient value to be considered as a specific difference. In the form of the plications and other characters of surface ornamentation the two species are essentially alike.

Horizon.—Chester group.

Spirifer increbescens Hall

Plate XLVI, Figs. 1-12

1858. *Spirifer increbescens* Hall, Geol. Iowa, vol. 1, pt. 2, p. 706, pl. 27, figs. 6a-i.
1858. *Spirifer increbescens* var. *transversalis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 708.
1883. *Spirifera increbescens* Hall, Rep. N. Y. State Geol. for 1882, pl (30) 55, figs. 27-30, pl. (31) 56, figs. 1-3.
1894. *Spirifer increbescens* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 27, figs. 8-11.
1894. *Spirifera increbescens* Keyes, Mo. Geol. Surv., vol. 5, p. 82.
1895. *Spirifer increbescens* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 30, figs. 27-30, pl. 31, figs. 1-3.
1909. *Spirifer increbescens* Bassler, Va. Geol. Surv., Bull. No. II A, pl. 29, figs. 1-3.
1911. *Spirifer increbescens* Girty, Bull. U. S. Geol. Survey No. 439, p. 68.

Description.—Shell of medium size, wider than long, greatest width along the hinge-line, the cardinal extremities angular, the valves subequally convex. The dimensions of two individuals are: length 31 mm. and 28 mm., greatest width along the hinge-line 40 mm. and 44 mm., thickness 23 mm. and 19 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface sloping abruptly from the more or less gibbous umbonal region to the cardinal margin and more gently to the antero-lateral margins, usually somewhat compressed towards the cardinal extremities but sometimes with the fullness extending throughout; beak pointed and incurved; cardinal area concave, becoming more curved towards the beak,

its height 3 to 4 mm., the inferior portion sloping posteriorly at an angle of about 135 degrees to the plane of the valve, the lateral margins sharply defined and curving gently from the beak, the curvature becoming more abrupt as it approaches the cardinal extremities, the area marked by vertical striæ and when perfectly preserved by fine crenulations along the cardinal margin; lateral slopes of the valve each bearing from 14 to 18 rounded plications which are usually simple except that the second one on each side originates from the outer side of the first one close up to the beak, and occasionally the third one is given off from the inner side of the fourth; the mesial sinus originates at the beak where it is sharply defined and angular, becoming rounder in the bottom anteriorly and less strongly defined, marked by a median plication which originates near the beak and continues to the anterior margin gradually increasing in size, each lateral slope of the sinus marked by one plication, or occasionally two, which originate from the inner margins of the lateral bounding plications, the lateral plications are usually weaker than the median one and when two are present the one which originates most anteriorly is much fainter than the other.

Brachial valve with its greatest convexity near the middle, the surface sloping more abruptly towards the cardinal margin, usually somewhat compressed towards the cardinal extremities; mesial fold sharply defined at the beak but scarcely elevated above the general surface of the valve, becoming gradually elevated to the front where it is rounded and of moderate height; it is marked by a median furrow corresponding with the median plication of the sinus, and usually with two plications on each side; the lateral slopes are marked by plications similar in form and number to those of the opposite valve.

The surface of both valves marked by exceedingly fine concentric and longitudinal lines which give it a finely reticulate appearance under a lens, and by coarser lines of growth which are sometimes crowded towards the anterior margin.

Remarks.—This species is most like *S. pellaensis,* but is always larger in its adult condition, with a greater number of plications, and does not exhibit so great variation in its general outline, being more uniformly extended along the hinge-line. The occasional division of one of the larger plications upon the lateral slopes of the shell is also a feature which has not been observed in *S. pellaensis.* Immature examples of *S. increbescens,* however, are almost identical in general form with the smaller species and may not possess a larger number of plications, but they may usually be recognized as immature by the lack of crowding of the lines of growth towards the anterior margin.

Horizon.—Chester group.

Spirifer leidyi Norwood and Pratten

Plate XLVII, Figs. 17-31

1855. *Spirifer Leidyi* Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., (2), vol. 3, p. 72, pl. 9, figs. 2a-c.
1883. *Spirifera Leidyi* Hall, Rep. N. Y. State Geol. for 1882, pl. (30) 55, figs. 25-26.
1894. *Spirifer Leidyi* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 27, figs. 16-17.
1894. *Spirifera leidyi* Keyes, Mo. Geol. Surv., vol. 5, p. 82.
1895. *Spirifer Leidyi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 30. figs. 25-26.

Description.—Shell below medium size, wider than long, the greatest width usually along the hinge-line, the cardinal extremities angular or rarely a little rounded, the valves subequally convex. The dimensions of two individuals are: length 21 mm. and 17.8 mm., width 27.5 mm. and 23 mm., thickness 15 mm. and 14.5 mm.

Pedicle valve with its greatest convexity posterior to the middle, the beak pointed and incurved; cardinal area concave, becoming more curved towards the beak, its height 2 to 3 mm., its inferior portion sloping posteriorly at an angle of about 115 degrees to the plane of the valve, the lateral margins sharply defined, sloping from the beak to the cardinal extremities in either a straight or gently curved line; lateral slopes of the valve convex, becoming a little compressed towards the cardinal extremities in the broader individuals, the surface curving more abruptly to the cardinal than to the antero-lateral margins, each lateral slope bearing from 7 to 10 angular plications, 8 being the more usual number, which grow gradually smaller towards the cardinal extremities, the second plications on each side, those next to the bounding plications of the sinus, originate near the beak from the outer side of the first plications, the remaining ones extend to the cardinal margin and are usually simple, although occasionally one of the larger ones, more often the fourth, bifurcates near the beak and gives origin to the third plication from its inner side; the mesial sinus originates at the beak where it is angular and sharply defined, becoming rather profound anteriorly, an angular median plication originates close to the beak and continues to the anterior margin with gradually increasing size, each of the lateral bounding plications gives rise, from its inner side near the beak, to a single plication which continues without division to the anterior margin; these lateral plications never attain the strength of the median one, they are much smaller and occasionally are nearly or quite obsolete.

Brachial valve equally or a little less convex than the pedicle, its greatest convexity near the middle, the surface curving more abruptly to the cardinal margin, usually becoming somewhat compressed towards the

cardinal extremities; mesial fold sharply defined at the beak, becoming strongly elevated in front, marked by a deep, angular, median groove, which gives it a distinctly bifurcate appearance, on each lateral slope of the fold is a single, much weaker plication; lateral slopes of the valve marked by plications similar in form and number to those of the opposite valve.

When perfectly preserved the surface of the entire shell is marked by minute raised concentric and longitudinal lines which give it a finely reticulate appearance when examined with a magnifying glass, the surface is also marked by stronger concentric lines of growth which are sometimes crowded anteriorly.

Remarks.—In general form and size this species resembles *S. pellaensis*, but it does not exhibit so great variation in outline as that species. It can be easily distinguished by its smaller number and much more angular plications, as well as by the conspicuously bifurcate median fold of the brachial valve. The species may be distinguished from immature examples of *S. increbescens*, with which it is sometimes associated, in much the same way as from *S. pellaensis*.

Horizon.—Chester group.

Spirifer bifurcatus Hall

Plate XLVII, Figs. 6-16

1856. *Spirifer bifurcata* Hall, Trans. Albany Inst., vol. 4, p. 8.
1866. *Spirifer Leidyi* var. *Merimacensis* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 410.
1882. *Spirifera bifurcata* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 47, pl. 6, figs. 13-15.
1883. *Spirifera bifurcata* Hall, 12th Rep. Geol. Surv. Ind., p. 326, pl. 29, figs. 13-15.
1895. *Spirifer keokuk* var. ? Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 37, figs. 13-15.
1906. *Spirifer bifurcatus* Beede, 30th Rep. Geol. Surv. Ind., p. 1314, pl 22, figs 13-15

Description.—Shell usually below medium size, wider than long or occasionally with the length and width subequal, greatest width usually along the hinge-line, cardinal extremities usually nearly rectangular, sometimes a little rounded. The dimensions of two individuals are: length 23 mm., and 12.8 mm., width 29 mm. and 17 mm., thickness 17.5 mm. and 9.5 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface sloping abruptly from the umbonal region to the cardinal margin, more gently to the antero-lateral margins, not at all or but slightly compressed towards the cardinal extremities; beak pointed and incurved; cardinal area concave, becoming more curved towards the beak, 2 to 4 mm. high, the inferior portion sloping posteriorly at an angle of about

115 degrees to the plane of the valve, the lateral margins sharply defined, sloping from the beak to the cardinal extremities, the surface vertically striated; lateral slopes of the valve each bearing from 5 to 8 simple angular plications, 6 or 7 being the most usual number, which become progressively weaker towards the cardinal extremities; mesial sinus well defined to the beak, becoming more or less profound anteriorly, marked by an angular median plication which originates near the beak and continues to the anterior margin with gradually increasing size, becoming nearly as strong as the larger plications upon the lateral slopes; in the larger individuals a single faint plication is sometimes present upon each of the lateral slopes of the sinus, originating from the lateral bounding plications.

Brachial valve with its greatest convexity near the middle, the surface sloping more abruptly to the cardinal margin, sometimes becoming a little compressed towards the cardinal extremities; mesial fold well defined to the beak, moderately or rather highly elevated anteriorly, marked by a profound median furrow which divides it into two sharply angular plications, occasionally a single much fainter plication is present upon each lateral slope of the fold in the larger individuals; the lateral slopes are marked by plications similar in form and number to those of the opposite valve.

Remarks.—This species was originally described from dwarfed individuals from the Spergen Hill fauna, the type specimen not exceeding 2.5 mm. in width. It occurs very generally in the Salem limestone, however, and is usually of much larger size than the type. The species is most closely allied to *S. leidyi*, in fact it was described by Swallow at one time as a variety of that species, *S. leidyi* var *merimacensis*, and Whitfield has expressed the opinion that the two species are not distinct. A careful study by the writer of many specimens of both species has forced the conclusion that the two forms are well worthy of recognition as distinct species, although they are doubtless genetically related, *S. bifurcatus* being the earlier and *S. leidyi* the later form. In *S. bifurcatus* the plications are usually less in number and somewhat coarser, and the lateral plications of the fold and sinus are usually obsolete except in the larger individuals. In *S. leidyi* the lateral plications of the fold and sinus are always present except in very rare instances. An occasional example of *S. bifurcatus* may be almost identical in its characters with some examples of *S. leidyi*, but when one compares the normal or average condition of a large number of individuals of both species, there is a distinct difference between the two, a difference which is sufficiently marked to be of specific rank, especially when the time relations of the two are taken into consideration.

Horizon.—Salem limestone.

Spirifer littoni Swallow

Plate L, Figs. 1-5

1860. *Spirifer Littoni* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 646.

Description.—Shell below medium size, longer than wide, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 20.4 mm., length of brachial valve 17 mm., greatest width 23 mm., length of hinge-line 16 mm., thickness 15.3 mm., height of cardinal area 3.5 mm.

Pedicle valve rather strongly convex, the greatest depth towards the umbo, the surface curving abruptly to the cardinal margin, more gently to the lateral and anterior margins, not compressed towards the cardinal extremities; beak small, pointed and rather strongly incurved; the cardinal area of moderate height, rather strongly arched, the curvature becoming greater towards the beak, the lateral margins not very sharply defined, the delthyrium large, about as wide as high; mesial sinus originating at the beak as a narrow, but well-defined depression, becoming rather broad and moderately deep to the front where it is somewhat produced in an anterior extension of the valve, it is marked by a mesial plication which originates near the beak as a very fine, elevated line, becoming rather broadly rounded, but not very high towards the front, and by a single, fainter, sometimes nearly obsolete plication, upon each side, which originates from the inner margin of the lateral bounding plications; the lateral slopes regularly convex, each marked by from eight to ten simple, rounded plications which grow successively smaller towards the cardinal extremities.

Brachial valve subelliptical in outline, its convexity about equal to or a little less than that of the pedicle valve, its greatest depth near or posterior to the middle, the umbonal region rather prominent and projecting beyond the cardinal margin, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, slightly compressed towards the cardinal extremities; cardinal area narrow; the beak rather strongly incurved; mesial fold originating at the beak as a flattened, scarcely elevated plication, it is well defined and becomes moderately elevated in front, with a rather broadly rounded mesial depression and usually a single fainter depression upon each side; the lateral slopes marked by simple, rounded plications entirely similar to those of the opposite valve.

The finer surface markings consist of rather inconspicuous concentric lines of growth, an occasional one of which is somewhat stronger than the others, and by an exceedingly fine reticulate marking which is only visible upon perfectly preserved surfaces.

Remarks.—This is one of the species which has never previously been illustrated, and which has not commonly been recognized. The type specimens have been lost, but the shells here referred to the species agree well with the original definition and occur in the St. Louis limestone, from which formation the types of the species were reported. The species resembles *S. bifurcatus* as closely as any other, but may be distinguished by its much less angular plications. It differs from *S. pellaensis* in its shorter hinge-line, rounded cardinal extremities, and in its stronger plications, especially the stronger median plication of the mesial sinus.

Horizon.—St. Louis limestone.

Spirifer marshallensis n. sp.

Plate L, Figs. 13-14

Description.—Shell small, wider than long, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of a brachial valve are: length 12 mm., width 18 mm., length of hinge-line ±14 mm., convexity 6 mm. The pedicle valve not known.

Brachial valve transversely subelliptical in outline, moderately convex, the greatest convexity near the middle, subcarinate along the median line, the umbonal region slightly produced beyond the hinge-line; mesial fold defined to the beak, scarcely elevated in the umbonal region, becoming moderately elevated anteriorly but not sharply differentiated from the general convexity of the valve, it is rounded in contour and is marked anteriorly by four obscure plications which unite into a single one in passing to the beak; lateral slopes convex antero-posteriorly, the curvature a little more abrupt to the cardinal margin, the slope from the middle of the mesial fold to the lateral margin at the widest part of the shell is very slightly convex or is nearly a straight line, giving the valve its subcarinate aspect, the surface is slightly compressed towards the cardinal extremities, each slope marked by 9 or 10 simple, depressed, rounded plications separated by rounded furrows about equaling the plications in width.

The minute surface markings of the specimens examined are not perfectly preserved, but the shell is apparently granulose, no concentric or radiating striæ of any sort are indicated.

Remarks.—In size and general form this species resembles *S. orestes* H. and W., from the Upper Devonian of Rockford, Iowa, but it may be distinguished by its less elevated and less angular median fold and by the more rounded cardinal extremities.

Horizon.—Kinderhook.

Spirifer keokuk Hall

Plate XLIX, Figs. 1-14

1852. *Spirifer attenuatus* Owen, Geol. Rep. Wis., Iowa, and Minn., tab. 3A, fig. 8.
1858. *Spirifer keokuk* Hall, Geol. Iowa, vol. 1, pt. 2, p. 642, pl. 20, figs. 3a-d, 2d.
1883. *Spirifera Keokuk* Hall, Rep. N. Y. State Geol. for 1882, pl (30) 55, figs. 21-22 (not figs. 23-24).
1894. *Spirifer Keokuk* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 27, figs. 14-15.
1894. *Spirifera keokuk* Keyes, Mo. Geol. Surv., vol. 5, p. 81, pl. 40, fig. 2.
1895. *Spirifer Keokuk* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 30, figs. 21-22 (not figs. 23-24).

Description.—Shell of medium size, wider than long, greatest width at or near the hinge-line, the cardinal extremities more or less nearly rectangular, sometimes rounded in the narrower specimens. The dimensions of two examples are: length 26.5 mm. and 26.8 mm., width 31 mm. and 35 mm., thickness 19.5 mm. and 19.5 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region broadly convex, the surface more or less compressed towards the cardinal extremities; beak pointed and rather strongly incurved; cardinal area concave, becoming more strongly curved as it approaches the beak, the inferior portion sloping posteriorly at an angle of about 135 degrees to the plane of the valve, about 4 to 5 mm. in height, the lateral margins sharply defined, sloping from the beak to the cardinal extremities first with a convex and then with a concave curvature; lateral slopes of the valve convex on either side of the sinus, curving abruptly to the cardinal margin, the curvature becoming concave as it approaches the cardinal extremities, each marked by from 11 to 15 rounded plications which become progressively smaller towards the cardinal extremities, all of them are simple except occasionally those which form the lateral boundaries of the sinus; mesial sinus shallow and rounded in the bottom near the beak, becoming deeper and broader anteriorly, sometimes produced anteriorly into a conspicuous nasute extension; near the beak a single median plication originates which usually continues to the anterior margin as a simple rounded rib, increasing regularly in size, occasionally this median rib bifurcates and continues to the anterior margin as two smaller rounded plications; on each side of the median rib may be seen one or perhaps two, usually weaker, plications upon the lateral slopes of the sinus, which originate from the inner lateral margins of the plications bounding the sinus.

Brachial valve a little less convex than the pedicle, greatest convexity near the middle, the surface sloping more abruptly from the umbo to the cardinal margin, becoming somewhat compressed towards the cardinal

extremities; mesial fold scarcely elevated above the general surface near the beak, often becoming rather highly elevated anteriorly, always rounded, marked by a shallow rounded median furrow corresponding with the median plication of the sinus, and by two or sometimes three plications on each side; lateral slopes marked by rounded plications which are similar in form and number with those of the opposite valve.

Surface of both valves marked by fine concentric lines which are more crowded and conspicuous towards the anterior margin and by occasional stronger lines of growth, also by very minute longitudinal striæ which give to the perfectly preserved surface, when viewed under a lens, a finely reticulate appearance.

Remarks.—Shells from various horizons in the Mississippian have commonly been referred to *S. keokuk*, but many of them have been incorrectly identified. The species seems to be closely confined to the Keokuk limestone and often occurs in great numbers in one zone near the summit of the limestone beds of the formation. The species may be easily distinguished from other related forms by reason of the rotund convexity of the umbonal region of the pedicle valve, and by the less angular sinus of the same valve near the beak.

Horizon.—Keokuk limestone.

Spirifer floydensis n. sp.

Plate XLIX, Figs. 15-19

Description.—Shell of medium size, wider than long, the greatest width at or near the hinge-line, the cardinal extremities nearly rectangular. The dimensions of two individuals are: length of pedicle valve 35.5 mm. and 31.5 mm., length of brachial valve 31 mm. and 25 mm., width 43 mm. and 35 mm., thickness ±24 mm. and 22 mm., height of cardinal area 4 mm. and 3.5 mm.

Pedicle valve strongly convex in the umbonal region, the greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin, more gently to the antero-lateral margins, somewhat compressed towards the cardinal extremities; beak small, attenuate, incurved; cardinal area of moderate height, arched, the curvature increasing towards the beak, the lateral margins sharply defined, sloping from the beak to the cardinal extremities in nearly a straight line or with a gently concave curve; lateral slopes convex towards the median sinus, becoming slightly compressed towards the cardinal extremities, each marked by from 15 to 20 depressed rounded plications, one or more of which may bifurcate between the umbonal region and the anterior margin, they grow successively smaller towards the cardinal extremities, the last 3 or 4 being very faint or sometimes almost obsolete; mesial sinus originating at the beak where it is simple and sharply defined, anteriorly it becomes

ill-defined and plicated, a median plication originates near the beak and continues without division to the anterior margin, on each side there are 4 or 5 plications which originate from the inner margins of the bounding plications or through the bifurcation of such plications.

Brachial valve about as convex as the pedicle, the greatest convexity near the middle, the surface becoming compressed towards the cardinal extremities; mesial fold defined to the beak, slightly elevated above the general surface of the valve in the umbonal region, becoming rather highly elevated in front, rounded or subangular along the median line, marked by plications similar to those of the sinus of the pedicle valve; lateral slopes most convex towards the umbonal region, marked by plications entirely similar in form and number to those of the opposite valve.

Remarks.—This species resembles *S. keokuk* in some respects, but besides usually growing to a larger size, its plications are more numerous on both the lateral slopes and the fold and sinus, they bifurcate more frequently and are not so strongly elevated as in that species. The minute surface markings of the shell are not sufficiently well preserved on either of the specimens examined to determine all their characters, but so far as they are preserved they are not unlike those of *S. keokuk*.

Horizon.—Knobstone formation of Indiana.

Spirifer indianensis n. sp.

Plate L, Figs. 6-12

Description.—Shell below medium size, longer than wide, the greatest width a little in front of the cardinal line, the cardinal extremities obtusely angular or rounded. The dimensions of a nearly complete example are: length 28.5 mm., width 22.5 mm., thickness 19 mm.; the dimensions of a perfect pedicle valve are: length 28 mm., width 25 mm., length of hinge-line 20 mm., convexity 12 mm.

Pedicle valve with its greatest convexity near or a little posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, more gently to the antero-lateral margins, the convexity of the valve extending out to the cardinal extremities; beak pointed and strongly incurved; cardinal area concave, becoming more curved towards the beak, its height 4 to 5 mm., its inferior portion sloping posteriorly at an angle of 140 degrees or more to the plane of the valve, the lateral margins defined, sloping from the beak to the cardinal extremities with a gently convex curve, the surface marked by vertical striæ; lateral slopes of the valve each bearing 9 or 10 simple, low, rounded plications which grow gradually smaller towards the cardinal extremities; the mesial sinus originates at the beak where it is shallow and rounded in the bottom, it becomes relatively shallower in the anterior half of the shell where it is often rather ill-defined, its anterior margin is produced into a nasute

extension, it is marked by a median plication which originates near the beak, or at least in the umbonal region, and continues to the anterior margin with gradually increasing strength, sometimes this median plication is the only one present in the sinus, but not infrequently there is a single lateral plication on each side which originates from the inner margins of the bounding plications, making three in all, the median plication is about equal in strength to the larger of the plications on the lateral slopes of the valve, the other two, when present, being somewhat weaker.

Brachial valve less convex than the pedicle, its greatest convexity posterior to the middle, the beak sharply pointed, extending a little beyond the hinge-line and slightly incurved over the narrow cardinal area, the surface of the valve sloping more abruptly to the cardinal margin, slightly or not at all compressed towards the cardinal extremities; mesial fold defined to the beak, but slightly elevated posteriorly, attaining a moderate height towards the anterior margin, where it has a rounded contour, marked by a single, shallow, rounded, median furrow, and sometimes by a still fainter one upon each lateral slope; the lateral slopes are marked by plications which are similar in size and number to those of the opposite valve.

The more minute surface markings are not well preserved upon the specimens, but there are fine concentric lines of growth towards the anterior margin, and occasionally stronger ones.

Remarks.—*S. indianensis* resembles *S. keokuk* in its type of surface markings, but it can be distinguished at once from that species by its elongate form. This elongation of the shell is rather an unusual form among the species of *Spirifer* in our Mississippian faunas, and the species may be recognized by this character alone, as there is no other closely allied species, with such a form.

Horizon.—Keokuk (Harrodsburg limestone of Indiana).

Spirifer rostellatus Hall

Plate XLVIII, Figs. 6-16

1858. *Spirifer rostellatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 641, pl. 20, figs. 2a-e.
1894. *Spirifera rostellata* Keyes, Mo. Geol. Surv., vol. 5, p. 82.
1895. *Spirifer rostellatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 32, fig. 5.

Description.—Shell of medium size, subovate to subelliptical in outline, varying from longer than wide to wider than long, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of a complete individual, the holotype of the species, are: length 27.5 mm.,

width 26 mm., thickness 15.5 mm., length of hinge-line 13 mm., height of cardinal area 3 mm. Other specimens are frequently proportionally much broader.

Pedicle valve with its greatest convexity posterior to the middle, the convexity extending out to the cardinal extremities, the umbonal region prominent but rather narrow, produced posteriorly beyond the hinge-line, the surface sloping abruptly from the umbonal region to the cardinal margin, more gently to the lateral and anterior margins; beak sharply pointed, narrow and incurved, its tip reaching the plane of the valve; cardinal area small, arched, the curvature becoming greater towards the beak, the lateral margins defined, sloping steeply from the beak to the cardinal extremities, the delthyrium large, broader than high, its width along the hinge-line a little less than one-half the total length of the hinge-line; lateral slopes each marked by 18 to 20 rounded plications which increase by bifurcation in the umbonal region and less frequently towards the front, they grow successively smaller towards the cardinal extremities where the last ones are nearly obsolete; mesial sinus narrow and well defined towards the beak, where it is without plications, anteriorly it is ill-defined, shallow and rounded in the bottom, a median plication originates in the umbonal region which increases by bifurcation to two or three at the anterior margin, each lateral slope of the sinus bears about three plications similar in form and size to the middle ones, one or two of which originate from the lateral margins of the bounding plications and the others from the bifurcation of these original ones.

Brachial valve wider than long, less convex than the pedicle, its greatest convexity near the middle, sometimes a little compressed towards the cardinal extremities; mesial fold defined to the beak but scarcely elevated above the general surface back of the middle of the valve, and only a little elevated in front where it is rounded in contour, marked by plications similar in form and number to those of the sinus in the opposite valve, all of which originate through the division of the single original plication at the beak; the lateral slopes gently convex, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are not well preserved, but exceedingly fine longitudinal striæ are suggested at one point upon the type specimen, and perhaps also some minute concentric lines. A few concentric lines of growth are usually present.

Remarks.—This shell can be easily recognized by its ovoid form, its short hinge-line and its narrow and protuberant umbonal region. In its surface markings it apparently resembles *S. grimesi* and *S. logani*, and its general form is in some respects a miniature of *S. grimesi* but with proportionally shorter hinge-line and finer plications.

Horizon.—Keokuk limestone.

SPIRIFER TENUIMARGINATUS Hall

Plate XLVIII, Figs. 1-5

1858. *Spirifer tenuimarginatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 641, pl. 20, figs. 1a-c.

1883. *Spirifera tenuimarginata* Hall, Rep. N. Y. State Geol. for 1882, pl. (32) 57, figs. 4-6.

1895. *Spirifer tenuimarginatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 32, figs. 4, 6.

Description.—Shell small, subovate or subrhombic in outline, wider than long, the greatest width at or close to the hinge-line, the hinge-line about equaling the greatest width of the shell, the cardinal extremities subangular. The dimensions of the holotype are: length of pedicle valve 19.5 mm., length of brachial valve 16.5 mm., width 21.8 mm., thickness 11.8 mm., height of cardinal area 2.5 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface a little compressed towards the cardinal extremities, the umbonal region prominent, produced posteriorly somewhat beyond the hinge-line, the surface sloping abruptly to the cardinal margin from the umbonal region, more gently to the antero-lateral margins; beak sharply pointed, narrow and incurved; cardinal area small, arched, the curvature becoming greater towards the beak, the lateral margins sharply defined, sloping steeply from the beak to the cardinal extremities, the delthyrium large, broader than high; lateral slopes each marked by about 20 angular plications with frequent bifurcations; mesial sinus ill-defined anteriorly, more sharply defined towards the beak, rounded in the bottom, shallow or of moderate depth, marked by about 12 plications similar to those on the lateral slopes, one plication originates at the median line near the beak and divides into two or three before reaching the anterior margin, the lateral plications originate from the inner margins of the bounding plications or through the bifurcation of plications so originating.

Brachial valve a little less convex than the pedicle, the greatest convexity near the middle, the surface compressed towards the cardinal extremities; mesial fold defined to the beak but scarcely elevated above the general surface in the posterior third of the valve, becoming strongly elevated in front, rounded in contour in the middle of the shell, becoming subangular towards the front, marked by plications similar in form and number to those of the sinus of the opposite valve, all of which originate through the division of the single original plication at the beak; lateral slopes gently convex, more or less flattened towards the cardinal extremities, marked by angular, bifurcating plications similar to those of the opposite valve.

The minute surface markings of the shell are not well preserved, but rather fine, concentric, perhaps sublamellose lines of growth are suggested, with a few stronger, concentric lines of growth.

Remarks.—This species is known to the writer only through a sulphur cast of the holotype. The entire aspect of this specimen strongly suggests a small and exceptionally narrow example of *S. tenuicostatus*, and it is not unlikely that such an interpretation of the specimen may be correct. Examples of *S. rostellatus* have sometimes been identified as *S. tenuimarginatus*, due to the fact that the figured type of S. *rostellatus* is an unusually narrow specimen of the species. The type of *S. tenuimarginatus* differs notably from *S. rostellatus* in its much finer and more angular plications and its proportionally much more elongate hinge-line.

Horizon.—Keokuk limestone.

Spirifer subrotundus n. nom.

Plate L, Figs. 15-22

1858. *Spirifer subrotundatus* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 521, pl. 7, fig. 8. (Not *S. subrotundatus* McCoy, 1855.)
1900. *Spirifer subrotundatus* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 76, pl. 2, figs. 8-10.

Description.—Shell of medium size, subcircular, subovate or subelliptical in outline, the width equal to, greater than, or less than the length, the hinge-line much shorter than the greatest width of the shell, the cardinal extremities rounded, the greatest width of the shell near its mid-length. The dimensions of two individuals are: length of pedicle valve 32 mm. and 35 mm., length of brachial valve 26 mm. and 28 mm., greatest width 37 mm. and 33 mm., thickness 18 mm. and 24 mm., height of cardinal area ±4.5 mm. and ±4 mm.

Pedicle valve more or less strongly convex, the convexity extending out to the cardinal extremities, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the antero-lateral margins; beak rather obtuse in the casts and more or less incurved; cardinal area of medium height, more or less arched, the lateral margins defined but doubtless less defined in the casts than in the shell itself, sloping from the beak to the cardinal extremities; lateral slopes each marked by 25 or more depressed, bifurcating plications which become faint or almost obsolete towards the cardinal extremities; mesial sinus ill-defined, shallow, rounded, sometimes scarcely more than a flattening of the median portion of the valve, marked by 10 or 12 plications similar in every respect to those of the lateral slopes.

Brachial valve a little less convex than the pedicle, the greatest convexity near or posterior to the middle, the surface curving rather abruptly from the umbonal region to the cardinal margin, and more gently to the antero-lateral margins, sometimes a little compressed towards the cardinal extremities; mesial fold low, ill-defined, scarcely raised above the general surface of the valve except sometimes towards the front,

marked by plications similar in form and number to those of the opposite valve; the lateral slopes marked by plications similar in all ways to those of the opposite valve.

The minute surface markings of the shell are not preserved in the condition of preservation in which all the examples have been found. Some concentric lines of growth of greater or less strength occur at irregular intervals.

Remarks.—This species has been observed only in the condition of internal casts in a fine-grained sandstone, a condition in which the more minute markings of the shell cannot be recognized. It is therefore impossible to determine whether or not the shell was marked by minute longitudinal striæ or corrugations such as are present in *S. grimesi, S. logani,* and *S. striatiformis.* In its completely plicated shell with similar, bifurcating plications on both fold and sinus and on the lateral slopes of the valves, the species resembles the above named forms, but it differs essentially from all of these in its size and proportions.

Hall's original designation of the species, *S. subrotundatus,* proves to have been preoccupied by McCoy, in consequence of which it is here called *S. subrotundus.*

Horizon.—Chonopectus sandstone of the Kinderhook.

Spirifer maplensis n. sp.

Plate LI, Figs. 3-8

Description.—Shell of medium size, usually longer than wide, and longitudinally subelliptical in outline, but occasionally individuals occur in which the length and breadth are nearly equal; the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of a medium sized pedicle valve are: length 29 mm., width 22 mm., convexity 10 mm., length of hinge-line 14 mm. The dimensions of a brachial valve are: length 25 mm., width 21 mm., convexity 6 mm. The dimensions of the largest example observed, a pedicle valve, are: length 37 mm., width 37 mm., convexity 16 mm.

Pedicle valve strongly and regularly convex, the convexity extending out to the cardinal extremities, the greatest convexity near or posterior to the middle; beak obtuse in the internal casts, reaching but a short distance back of the hinge-line; character of the cardinal area not well shown in the specimens, but it is evidently low and small; lateral slopes of the valve sloping abruptly with a convex curvature from near the mesial sinus to the lateral margins, the surface becoming nearly vertical to the plane of the valve near the margin, the curvature to the cardinal margin more abrupt than to the lateral margin, each lateral slope marked by from 20 to 25 flattened, radiating plications which increase by bifurcation in passing towards the anterior margin, and decrease in size to-

wards the cardinal extremities; mesial sinus shallow, narrow, rounded in the bottom, ill-defined laterally, marked by from 6 to 10 plications similar in every respect to those upon the lateral slopes.

Brachial valve less convex than the pedicle, its depth usually not more than one-half that of the pedicle valve, its surface is gently convex across the middle portion, but curves abruptly to the lateral margins and to the cardinal margin, sometimes a little compressed towards the cardinal extremities; the mesial fold is depressed, being scarcely elevated above the general surface of the valve in its posterior half, it is rounded in contour and ill-defined laterally, it is marked by plications similar in form and number to those of the opposite valve.

The minute surface markings are not preserved in the casts, but the presence of concentric lines of growth are indicated which become crowded near the anterior margin

Remarks.—This species has been observed only in the form of casts in a fine-grained yellow sandstone. It may be distinguished from *S. subrotundus*, the species which it most closely resembles, by its more elongate form, its shallower fold and sinus, its flatter plications, and by the lateral compression of the shell. The surfaces of the lateral slopes of the two valves of *S. subrotundus* meet at the lateral margins of the shell in an acute angle while in this species the angle is at most obtuse and is usually absent because of the inflection of the lateral margins of the valves to form a flattened area towards the cardinal extremities. The peculiar elongate form of the species, with its completely plicated shell and shallow fold and sinus, resembles in some degree the elongate, short-hinged varieties of the Devonian species, *S. hungerfordi*. The species also resembles in its elongate form and general proportions, the Russian species *S. mosquensis* Fisch., but does not grow so large as that species. The relationships of neither this species nor *S. subrotundus* with the completely plicated Spirifers of the *S. striatus* type, represented in American faunas by *S. grimesi* and *S. logani*, can be determined, since the minute longitudinal striæ of those species cannot be detected on specimens preserved as these are.

Were the shell itself preserved in this species, it is not improbable that a larger number of plications would be shown; in the condition of preservation of the specimens about 50 plications can usually be detected about the margin of the shell, including those on the sides and in the fold and sinus, they grow faint and disappear before reaching the cardinal extremities, and on the shell surface itself as many as ten or more additional ones would probably be seen.

Horizon.—English River grit of the Kinderhook.

Spirifer gregeri n. sp.

Plate LV, Figs. 1-8

Description.—Shell above medium size or rather large, usually a little longer than wide but sometimes wider than long, the hinge-line shorter than the greatest width, the lateral margins usually slightly sinuate just in front of the obtusely angular cardinal extremities. The dimensions of a nearly complete pedicle valve, a partial internal cast, are: length 55 mm., greatest width 53 mm., length of hinge-line 38 mm., convexity 22 mm., height of cardinal area 6 mm.

Pedicle valve subhemispherical, the greatest depth near the middle, the surface curving rather abruptly in all directions from the center of the valve, becoming very slightly compressed towards the cardinal extremities; beak small, rather strongly incurved; the cardinal area of moderate height, concave, the curvature increasing towards the beak, the lateral margins sharply defined, sloping gradually from the beak nearly to the cardinal extremities, where they bend abruptly to the hinge-line, truncating the lateral extremities of the area; mesial sinus inconspicuous at the beak, becoming more pronounced anteriorly, it is usually narrow and of moderate depth, rounded in the bottom and not sharply defined laterally, sometimes scarcely more than a mesial flattening of the valve; the entire surface of the valve, both the lateral slopes and the mesial sinus, marked by depressed rounded plications which bifurcate frequently, they vary in width from less than one to one and one-half millimeters, from 25 to 30 or more occupy each lateral slope and about 12 the mesial sinus.

Brachial valve with the convexity about equal to the pedicle, the greatest depth posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins, slightly compressed towards the cardinal extremities; the cardinal area narrow; the beak obtusely pointed and moderately incurved; the mesial fold inconspicuous in the posterior half of the valve, becoming moderately elevated anteriorly, not sharply defined laterally; the surface of the valve marked by plications entirely similar in form and number to those of the opposite valve.

The minute surface markings of both valves consist of extremely fine radiating striæ which are often entirely obliterated in fossilization. Concentric lines of growth are present which are unevenly distributed and vary in strength.

Remarks.—This species resembles *S. grimesi* in some respects, but it is a smaller shell with much more rotund form, especially with a much more conspicuously subhemispherical pedicle valve and a narrower mesial sinus.

Horizon.—Lower Burlington limestone.

Spirifer rowleyi n. sp.

Plate LIII, Figs. 3-6; Plate LIV, Figs. 1-4

1909. *Spirifer grimesi* Weller, Bull. Geol. Soc. Am., vol. 20, p. 304, pl. 13, figs. 1-2.

Description.—Shell large, broader than long, transversely subelliptical in outline, the hinge-line shorter than the greatest width, the cardinal extremities subangular or rounded. The dimensions of a nearly complete but somewhat distorted specimen are: length of pedicle valve about 55 mm., length of brachial valve about 47 mm., greatest width about 75 mm., length of hinge-line about 55 mm., thickness +32 mm.

Pediele valve rather strongly eonvex, the greatest depth posterior to the middle, the umbonal region narrow, the surfaee eurving abruptly to the cardinal margin each side of the beak, beeoming somewhat eompressed towards the eardinal extremities, curving more gently to the lateral and anterior margins; the beak very small and strongly ineurved; eardinal area of moderate height, nearly flat towards the eardinal margin but becoming rather strongly eoneave towards the beak, the lateral margins sharply defined, subparallel with the eardinal margin for the greater part of their length; mesial sinus originating as a narrow and sharply defined furrow at the beak, beeoming broader, less sharply defined and rather deep anteriorly where it is rounded in the bottom and somewhat produeed as a rounded anterior extension of the valve; lateral slopes and sinus marked by depressed, rounded, radiating plications whieh bifureate frequently, they are from one to two millimeters in width, from 25 to 30 oeeupying eaeh lateral slope, and 20 or more the mesial sinus at the front margin.

Brachial valve subelliptieal in outline, a little less eonvex than the pedicle, its greatest depth near the middle, the surfaee eompressed towards the eardinal extremities; the cardinal area very narrow and linear; the mesial fold well defined to the beak, seareely elevated above the general surfaee in the umbonal region, beeoming strongly elevated in front and sometimes slightly reeurved, its lateral boundaries less sharply defined anteriorly than towards the beak; the entire surfaee of the valve marked by flattened, bifureating plieations entirely similar in form and number to those of the opposite valve.

The minute surfaee markings of the shell are exeeedingly fine radiating striæ, twenty of whieh sometimes oeeupy the width of a single plieation.

Remarks.—This speeies has been identified commonly as *S. grimesi*, but it may be easily distinguished from that speeies by its narrower umbonal region and more pointed beak, and by the narrower, deeper and more sharply defined mesial sinus. The minute radiating striæ are also usually

more conspicuous upon members of this species, although this may be due to the difference in preservation.

Horizon.—Fern Glen formation and lower Burlington limestone.

Spirifer grimesi Hall

Plate LI, Figs. 1-2; Plate LII, Figs. 1-4; Plate LIII, Figs. 1-2.

1858. *Spirifer grimesi* Hall, Geol. Iowa, vol. 1, pt. 2, p. 604, pl. 14, figs. 1-5.
1883. *Spirifera Grimesi* Hall, Rep. N. Y. State Geol. for 1882, pl. (31) 56, figs. 8, 16-19.
1894. *Spirifera grimesi* Keyes, Mo. Geol. Surv., vol. 5, p. 79.
1895. *Spirifer Grimesi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 30, figs. 8, 16-19.

Description.—Shell large, varying from longitudinally to transversely subelliptical in outline, the length sometimes greater but usually less than the width, the hinge-line shorter than the greatest width, the cardinal extremities rounded or obtusely angular. The dimensions of two individuals, the smaller one the type of the species, are: length 88 mm. and 85 mm., width 100 mm. and 77 mm., thickness 61 mm. and 53 mm., length of hinge-line 80 mm. and 52 mm., height of cardinal area 8 mm and 8 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the surface sloping abruptly from the rather broad umbonal region to the cardinal margin, and more gently to the antero-lateral margins, sometimes a little compressed towards the cardinal extremities; beak rather obtusely pointed and incurved; cardinal area of moderate height, arched, the curvature becoming stronger towards the beak, sometimes almost flat towards the hinge-line, the lateral margins very sharply defined, sloping from the beak to the cardinal extremities, the slope becoming more abrupt distally, the delthyrium large, broader than high; lateral slopes convex, becoming more or less flattened towards the cardinal extremities, covered with depressed, rounded, bifureating plications; mesial sinus rather broad and shallow, usually rounded but sometimes somewhat angular in the bottom, originating near the beak where it is rather sharply defined when the surface of the shell has not been eroded, loosing its definition anteriorly, sometimes produced in front into a nasute or lingual extension, its surface covered with bifureating plications like those on the lateral slopes.

Brachial valve about as convex as the pedicle, the greatest convexity near the middle; the lateral slopes convex, becoming somewhat compressed towards the cardinal extremities, marked by depressed, rounded plications like those of the opposite valve; the mesial fold broad, rounded, ill-defined, sometimes becoming strongly elevated and somewhat angular towards the front, originating at the beak where it is scarcely or not at all elevated above the general surface of the valve, marked with plications like those upon the lateral slopes of the shell.

Surface of each valve marked by 80 or more depressed, rounded, bifurcating plications, about 20 to 25 of which occupy the fold and sinus. The minute surface markings consist of exceedingly fine radiating striæ, about 6 to 10 of which occupy each plication, and by still finer concentric striæ which give to the surface of perfectly preserved shells a finely cancellated ornamentation. Concentric lines of growth are usually distributed over the surface of the shell in an irregular manner, often becoming somewhat crowded anteriorly.

Internally the muscular impressions in the pedicle valve are strongly impressed, the muscular area is more or less rhombic in outline but varies greatly in proportionate width, in some individuals being twice as wide as in other shells of approximately the same size. The dental lamellæ are short and more or less widely divergent, the divergence dependent upon the width of the muscular area; between the dental lamellæ towards the beak, at least in old individuals, there is a secretion of calcareous matter which completely solidifies the shell in that region, this solidification, however, does not extend out to the plane of the surface of the cardinal area, its posterior surface appearing as a transverse area with a median keel or ridge, somewhat deeply depressed in the upper part of the delthyrium, its lower margin being angularly notched.

Remarks.—This species is one of the most common and characteristic fossils of the Burlington limestone, but it usually occurs in a more or less fragmentary condition. Specimens preserving both valves are exceedingly rare, the most common examples being specimens of the pedicle valve which are more or less incomplete about the margin. The nearest relative of *S. grimesi* in the faunas of the Mississippi valley is *S. logani* of the Keokuk limestone, and in the fragmentary condition in which both species are usually preserved it is often difficult to properly distinguish between them. With complete or fairly complete examples of the two species, it is seen that *S. grimesi* is characterized by the shorter hinge-line, rounded cardinal extremities, and proportionally more elongate shell. The elongation of the shell is a variable character in the species as is indicated by the measurements of the two examples given above, the type specimen being an extreme form in which the length is greater than the width, the more usual condition is shown by the measurements of the larger individual having the width greater than the length. From the characters mentioned, especially the proportionate length of the hinge-line, it is not infrequently possible to identify the incomplete examples of the species as they usually occur, since one or more lines of growth can usually be detected. If these lines converge as they approach the cardinal margin the species is clearly a member of the species *S. grimesi,* but if they diverge it is *S. logani.*

Horizon.—Burlington limestone.

Spirifer logani Hall

Plate LVI, Figs. 1-3; Plate LVII, Figs. 1-3

1858. *Spirifer logani* Hall, Geol. Iowa, vol. 1, pt. 2, p. 647, pl. 20, fig. 7; pl. 21, figs. 1a-b, 2.
1863. *Spirifer lævigatus* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 86.
1883. *Spirifera Logani* Hall, Rep. N. Y. State Geol. for 1882, pl. (32) 57, figs. 7, 8.
1894. *Spirifer Logani* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 26, fig. 10.
1894. *Spirifera logani* Keyes, Mo. Geol. Surv., vol. 5, p. 81.
1895. *Spirifer Logani* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 32, figs. 7, 8.

Description.—Shell large, wider than long, the greatest width along the hinge-line, the cardinal extremities usually acutely angular or acuminate, sometimes rectangular. The dimensions of two individuals are: length 80 mm. and 61 mm., width 120 mm. and 88 mm., thickness 53 mm. and 40 mm., height of cardinal area 9.5 mm. and 9 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the surface sloping abruptly from the broad umbonal region to the cardinal margin, and rather gently to the lateral and anterior margins, distinctly flattened towards the cardinal extremities; beak rather obtusely pointed and incurved; cardinal area of moderate height, arched, the curvature becoming stronger towards the beak, sometimes nearly or quite flat towards the hinge-line, the lateral margins sharply defined, sometimes nearly parallel with the hinge-line through the greater part of the length and then sloping abruptly to the cardinal extremities, in other specimens sloping somewhat gradually from the beak to the cardinal extremities; the delthyrium large, broadly triangular, sometimes twice as wide at its base as the total height; lateral slopes convex towards the median part of the valve, becoming concave towards the cardinal extremities, covered with depressed, rounded, bifurcating plications from 1 to 2 mm. in width; mesial sinus broad and usually rather shallow, rounded in the bottom, originating near the beak, its lateral boundaries indefinitely marked, produced into a nasute extension anteriorly, its surface covered with bifurcating plications similar to those upon the sides of the shell.

Brachial valve about as convex as the pedicle, its greatest convexity near the middle; the lateral slopes convex towards the middle part of the shell, becoming concave or flattened towards the cardinal extremities, marked by depressed, rounded, bifurcating plications like those on the opposite valve; mesial fold broad, rounded, ill-defined, sometimes becoming strongly elevated towards the front and somewhat angular,

originating at the beak where it is scarcely or not at all elevated above the general surface of the valve, marked by plications similar to those upon the lateral slopes of the valve.

Surface of each valve marked by 80 or more depressed, rounded, bifurcating plications, about 20 to 25 of which occupy the fold and sinus. The minute surface markings consist of exceedingly fine radiating striæ, about 6 to 10 of which occupy each plication, and by still finer concentric striæ which give to the surface of perfectly preserved shells a finely cancellated ornamentation. Concentric lines of growth are usually distributed over the surface of the shell in an irregular manner, often becoming somewhat crowded anteriorly.

Remarks.—This species has its nearest ally in the Mississippi basin in *S. grimesi*, these two Spirifers being the largest members of the genus in America. In their surface ornamentation the two species are essentially identical, the distinction between them being found in the greater length of the hinge-line in *S. logani* and in its proportionally broader shell. In their internal characters the two species are also essentially alike, although the muscular impressions in the pedicle valve of *S. logani* are sometimes proportionally broader and shorter. In their stratigraphic relations *S. logani* is characteristic of the Keokuk limestone, while *S. grimesi* is a member of the next older fauna of the Burlington limestone.

Horizon.—Keokuk limestone.

Spirifer striatiformis Meek

Plate XLVIII, Figs. 17-21

1875. *Spirifer* (*Trigonotreta*) *striatiformis* Meek, Pal. Ohio, vol. 2, p. 289, pl. 14, figs. 8a-e.
1888. *Spirifer striatiformis* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 44, pl. 1, fig. 6; pl. 3, figs. 23-26; pl. 6, figs. 6, 7; pl. 12, fig. 20.
1888. *Spirifer striatiformis* Herrick, Bull. Sci. Lab. Denison Univ., vol. 4, pl. 2, fig. 9.
1895. *Spirifer striatiformis* Herrick, Geol. Surv. Ohio, vol. 7, pl. 15, fig. 9.

Description.—Shell of medium size, wider than long, the greatest width at or near the hinge-line, the lateral margins usually meeting the hinge-line in nearly a right angle and rounding to the front, the anterior margin rounding, usually projecting a little in the middle. The dimensions of a nearly perfect specimen are: length of pedicle valve 35 mm., length of brachial valve 28 mm., width ±46 mm., thickness 25 mm., height of cardinal area 5 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the umbonal region rather broad, the surface curving rather abruptly to the cardinal margins for a short distance on each side of the beak, curving more gently to the antero-lateral margins, somewhat

compressed towards the cardinal extremities, with a more or less ill-defined sinuosity passing obliquely from each side of the beak to the lateral margins just in front of the cardinal extremities; beak small, acuminately pointed, strongly incurved; cardinal area of medium height, arched and sloping posteriorly, the curvature becoming greater towards the beak, the lateral margins sharply defined, sloping from the beak to the cardinal extremities in a convex curve which becomes more abrupt distally; lateral slopes each marked by about 25 depressed, rounded plications which bifurcate more or less frequently anywhere between the cardinal and anterior margins, but more frequently towards the beak, these plications grow successively smaller towards the cardinal extremities, the smaller ones sometimes becoming very faint or almost obsolete; mesial sinus shallow, narrow and sharply defined at the beak, becoming broad and ill-defined anteriorly, marked by a median plication which originates near the beak and which usually divides into two anteriorly, on each side there are four or five plications which originate from the inner margins of the bounding plications or through the bifurcation of plications so originating, making 10 to 12 plications altogether in the sinus which are similar in all respects to those of the lateral slopes.

Brachial valve less convex than the pedicle, the greatest convexity near or posterior to the middle, the surface curving rather abruptly from the umbonal region to the cardinal margin, sloping with a much more gentle curve to the antero-lateral margins, somewhat compressed towards the cardinal extremities; mesial fold defined to the beak, depressed and but slightly raised above the general surface of the valve posteriorly, becoming more elevated and rounded anteriorly but less sharply defined; marked by plications similar in form and number to those of the opposite valve, all of which originate through the division of a single one at the beak; lateral slopes marked by plications similar in form and number to those of the opposite valve.

The minute surface markings consist of exceedingly fine longitudinal, rounded corrugations variable in width, the coarser ones generally in the furrows between the plications, from 8 to 12 occupying the space of 1 mm., crossing these are minute sublamellose concentric markings somewhat further apart than the longitudinal corrugations. A few concentric lines of growth are present at irregular intervals.

Remarks.—This species was originally described from the Waverly of Ohio, and the description given above has been written from such specimens. Other specimens from the Chouteau limestone in Missouri have been identified with the Ohio shell, although none have been seen which are so complete or so well preserved as some of the Ohio examples. So far as they are preserved the Chouteau limestone specimens agree closely in almost every respect with the authentic examples of the species, they

are similar in size and proportions and possess the same form of minute radial corrugations, but the more minute concentric markings have been almost obliterated in all specimens examined. The mesial sinus in the pedicle valve of the Chouteau limestone examples is perhaps slightly more angular than in the Ohio specimens, but without more evidence this character is not of enough importance to justify a specific differentiation.

Horizon.—Waverly group and Chouteau limestone of the Kinderhook

Spirifer mortonanus Miller

Plate LVIII, Figs. 1-3; Plate LIX, Figs. 1-6

1870. *Spirifer fastigatus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 36. (Not *S. fastigatus* Morton, 1836.)
1875. *Spirifer fastigatus* Meek and Worthen, Geol. Surv. Ill., vol. 6, p. 521, pl. 30, fig. 3.
1883. *Spirifera mortonana* Miller, Am. Pal. Foss., 2nd ed., p. 298.
1895. *Spirifer Mortonanus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 38, figs. 18, 19.

Description.—Shell above medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of two individuals are: length 39 mm. and 34 mm., width 69 mm. and 63 mm., thickness 35 mm. and 27.5 mm., height of cardinal area 8 mm. and 6 mm. The width of the largest specimen observed is 96 mm.

Pedicle valve convex in the middle on each side of the sinus, the curvature usually becoming a little more abrupt as it approaches the anterolateral margins, the surface becoming compressed or concave towards the cardinal extremities, often developing a more or less distinct oblique sinus on each side passing from near the beak to the lateral margins just in front of the cardinal extremities, the umbonal region rather broad; beak small and pointed, incurved; cardinal area rather high, arched, the curvature increasing towards the beak, the inferior portion sloping posteriorly at an angle of about 120 degrees to the plane of the valve, the lateral margins sharply defined, extending laterally from the beak with a very slight slope, being sub-parallel with the cardinal margin nearly to the end, where they drop off abruptly to the cardinal extremities; delthyrium large, wider than high, the surface of the area vertically striate and marked by faint, longitudinal lines of growth; lateral slopes of the valve each marked by from 10 to 12 rounded or subangular plications near the beak which grow gradually smaller towards the cardinal extremities, beyond them a considerable area of the shell is marked by much finer plications, 6 or 8 of which can be detected in some individuals, while in others they are nearly obsolete, from 2 to 6 of the larger plications on each lateral slope divide in the umbonal region and continue

more or less distinctly in pairs to the anterior margin of the shell; mesial sinus subangular or somewhat rounded in the bottom, defined to the beak, often produced anteriorly in a nasute or lingual extension, the plications usually somewhat fainter than the larger ones on the lateral slopes; they consist of a median one which originates near the beak and passes without division to the anterior margin; on each side of the sinus there are two or three lateral plications which are given off serially from the inner margins of the bounding plications.

Brachial valve equally or a little more convex than the pedicle, its greatest convexity near or in front of the middle; mesial fold sub-angular or sometimes rounded, well defined to the beak, moderately or rather highly elevated anteriorly, marked by a median furrow corresponding to the median plication of the opposite valve, and by three or four lateral plications, all of which join to form a single one at the beak; lateral slopes each convex towards the mesial fold, becoming flattened or a little concave towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings consist of fine concentric lines which are somewhat irregular in the strength of their development, and by occasional much stronger lines of growth.

Internally the muscular impressions of the pedicle valve are broadly ovate and deeply impressed, the shell in the umbonal and cardinal regions being much thickened.

Remarks.—This species is especially characteristic of the Crawfordsville shale of Keokuk age. It is characterized by its elongate hinge-line which in young individuals is distinctly acuminate, by the rather broad area of the pedicle valve with subparallel margins, and by the rather coarse, dividing plications.

Horizon.—Keokuk (Crawfordsville beds of Indiana).

Spirifer montgomeryensis n. sp.

Plate LV, Fig. 9

Description.—Shell above medium size, wider than long, the greatest width along the hinge-line, the cardinal extremities angular, acuminate in the type specimen. The dimensions of a pedicle valve are: length 37 mm., width 75 mm., convexity 15.5 mm., height of cardinal area 7 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the umbonal region broad, the surface curving abruptly to the cardinal margin for a short distance on each side of the beak, the curve to the antero-lateral margins gentle, somewhat compressed toward the cardinal extremities; beak small, acuminate, moderately incurved; cardinal area gently arched, the curvature becoming stronger toward the beak, its lateral margins sharply defined, sloping gently from the beak

distally, the slope becoming much more abrupt as it approaches the cardinal extremities; delthyrium large, broader than high; lateral slopes with a more or less distinct sinuosity extending obliquely from each side of the beak to the lateral margins just in front of the cardinal extremities, each marked with about 25 rounded or subangular plications, 5 to 8 of which towards the sinus are double, with about 10 additional single ones towards the cardinal extremities, the last 3 or 4 of which are but faintly developed, the double plications bifurcate in the umbonal region and continue in pairs to the anterior margin, the grooves between the pairs being distinctly wider and deeper than those between the two plications of each pair; mesial sinus distinctly defined from the beak to the anterior margin, subangular in the bottom, marked by a median plication which originates near the beak and continues without division to the anterior margin, on each side of the sinus there are 3 or 4 plications which originate from the inner margin of the bounding plications or from the bifurcation of such plications.

Brachial valve not observed.

The surface markings of the shell consist of fine, sublamellose, concentric lines which are crowded at intervals to form more or less conspicuous lines of growth.

Remarks.—This species is more closely allied to *S. mortonensis* than to any other, but it may be easily separated from that species by means of the distinctly duplicate plications which occupy a considerable area on each side of the sinus, and by the more sharply defined mesial sinus of the pedicle valve.

Horizon.—Keokuk (Harrodsburg limestone of Indiana).

Spirifer calvini n. sp.

Plate LIV, Figs. 5-10

Description.—Shell of medium size, wider than long, the greatest width at or near the hinge-line, the cardinal extremities angular or a little rounded. The dimensions of a nearly complete individual, slightly distorted in such a manner as to reduce the length and increase the thickness, are: length of pedicle valve 29 mm., length of brachial valve 24.5 mm., width 45.5 mm., thickness 30.5 mm., height of cardinal area 8 mm.

Pedicle valve subpyradimal in form, the umbo prominent; beak pointed, more or less incurved, sometimes a little twisted; cardinal area high, concave, marked by longitudinal lines of growth, the lateral margins defined but sometimes curving rather abruptly into the lateral slopes, sloping from the beak to the cardinal extremities in a slightly convex curve, the delthyrium large, broadly triangular; lateral slopes convex, sloping steeply from the umbonal region to the antero-lateral margins, each marked by from 12 to 14 simple, depressed convex, plications which are

separated by grooves narrower than the plications themselves; mesial sinus rather shallow or of moderate depth, flattened or rounded in the bottom, rather sharply defined at the beak but becoming ill-defined anteriorly, marked by 4 or 5 much flattened plications separated by narrow grooves.

Brachial valve shallower than the pedicle, with a narrow cardinal area; mesial fold depressed convex, sharply defined but scarcely elevated in the umbonal region, becoming moderately elevated towards the front, marked by much flattened plications similar in form and number to those of the sinus of the opposite valve; lateral slopes most convex towards the center of the valve, usually becoming a little compressed towards the cardinal extremities, the surface curving abruptly from the umbonal region to the cardinal margin, the slope more gentle to the antero-lateral margins, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings consist of fine granules which are somewhat elongate longitudinally. Rather fine concentric lines of growth are also present which are crowded at intervals, especially towards the front, to form stronger growth lines.

Remarks.—The fine surface markings of this species are usually destroyed through the exfoliation of the shell. The species is quite unlike any other Mississippian species of the genus, being especially characterized by the elevated beak, the high cardinal area, and the much flattened plications of the fold and sinus, these plications being much more depressed than those upon the lateral slopes of the shell.

Horizon.—Kinderhook.

Spirifer jeffersonensis Weller

Plate XLII, Figs 17-21

1906. *Spirifer jeffersonensis* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 444, pl. 6, figs. 18-22.

Description.—Shell below medium size, wider than long, the hinge-line a little shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete pedicle valve are: length 18 mm., greatest width 22.5 mm., length of hinge-line 21.5 mm., height of cardinal area 7 mm., convexity 11 mm. The dimensions of a brachial valve are: length 15 mm., width 22 mm., convexity 6 mm.

Pedicle valve strongly convex with the greatest depth towards the umbonal region, the surface curving gently from the umbo to the anterior and antero-lateral margins and more abruptly to the cardinal margin, scarcely compressed towards the cardinal extremities; the beak obtusely pointed and incurved; cardinal area high, concave, with the curvature

increasing towards the beak, the lateral margins not sharply defined, the surface of the area rounding into the surface of the lateral slopes; the delthyrium large and broadly triangular; the mesial sinus of moderate depth, rounded in the bottom, well defined laterally and continuing to the beak, it is marked by two more or less indistinct, sometimes nearly obsolete plications; lateral slopes each marked by from 8 to 12, usually 9 or 10 simple, rounded plications.

Brachial valve subelliptical in outline, moderately convex, the greatest depth posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the anterior and antero-lateral margins, very slightly or not at all compressed towards the cardinal extremities; mesial fold sharply defined to the beak but scarcely elevated above the general surface in the posterior half of the valve, becoming moderately elevated anteriorly, it is marked by three or four, low, rounded, indistinct plications which often appear to be almost obsolete; the lateral slopes marked by simple, rounded plications entirely similar in form and number to those of the opposite valve.

The finer surface markings consist of minute concentric lines of growth, which are usually nearly or quite destroyed by the exfoliation of the shell.

Remarks.—In its high cardinal area and inconspicuous plications on the fold and sinus this species suggests the genus *Syringothyris*, but it lacks the syrinx and the punctate shell structure of that genus. At one time it was believed that certain specimens in the Bushberg sandstone, in which the presence of a syrinx is clearly shown, were examples of this species, and that the species should therefore be transferred to *Syringothyris*,[1] but later observations have demonstrated that the two forms are not the same, and that this species is a true *Spirifer* and the other a genuine *Syringothyris*.

Horizon.—Glen Park limestone of the Kinderhook.

Genus *BRACHYTHYRIS* McCoy

Description.—Shells varying in size from small to large, the length and width subequal, the outline ovate to subcircular; the hinge-line straight, much shorter than the greatest width of the shell, the cardinal extremities rounded. Mesial sinus of the pedicle valve and the fold of the brachial valve more or less well developed. Surface of both valves marked by radiating plications which are simple upon the lateral slopes of the valves, those of the fold and sinus increasing in number in passing from the beak to the front margin. The pedicle valve with the beak usually only moderately elevated above the hinge-line, and the cardinal area rather strongly arched. Internally, the dental lamellæ supporting

[1] Jour. Geol., vol. 17, p. 272. (1909.)

the hinge-teeth are short, commonly being only ridge-like thickenings of the inner surface of the valve on each side of the delthyrium, the muscular scars ill-defined. The brachial valve commonly less convex than the pedicle, with a very narrow, inconspicuous cardinal area, the cardinal process low, with its anterior surface vertically striated; the form of the brachidium as in *Spirifer*.

Remarks.—The genus *Brachythyris* was proposed by McCoy in 1862, for the ovate, short-hinged Spirifers of which *S. ovalis* Phill. was figured as a typical form, and which must be assumed as the genotype, as has been pointed out by Buckman.[1] The shells of this type constitute a well defined group of species which may be conveniently separated from *Spirifer* proper, although it has usually been the custom to consider the name as strictly synonymous with *Spirifer*. In the American Mississippian faunas *Spirifer suborbicularis* is a typical member of the genus.

Brachythyris burlingtonensis n. sp.

Plate LIII, Figs. 8-9; Plate LXXXIII, Fig. 6

1901. *Spirifer peculiaris* ? Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 165, pl. 14, figs. 6-9.

Description.—Shell small, longitudinally semielliptical in outline, the hinge-line usually a little shorter than the greatest width of the shell, the greatest width posterior to the middle, the cardinal extremities usually rounded. The dimensions of a small, nearly complete internal cast, are: length of pedicle valve 11.5 mm., length of brachial valve 11 mm., greatest width 13.3 mm., length of hinge-line 10 mm., thickness 9 mm., height of cardinal area 2 mm. The dimensions of a larger pedicle valve are: length 19.5 mm., greatest width 18 mm., length of hinge-line 13 mm., convexity 8 mm., height of cardinal area 2.5 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbo prominent, the surface curving abruptly to the cardinal margin and more gently to the antero-lateral margins, slightly or not at all compressed towards the cardinal extremities; beak small, pointed, incurved; cardinal area small, arched, the curvature increasing towards the beak, lateral margins sloping from the beak to the cardinal extremities, scarcely defined, the surface of the area curving with little or no demarcation into the lateral slopes of the valve; lateral slopes convex, marked by from 8 to 10 simple, rounded, depressed plications which grow fainter towards the cardinal extremities; mesial sinus narrow, shallow, flattened in the bottom, sometimes but little more than a flattening of the valve along its median line, bounded by a pair of plications which are notably broader and stronger than those of the lateral slopes, smooth in

[1] Science, new ser., vol. 26, p. 379. (1907.)

the smaller individuals but in the larger ones marked by a more or less obscure median plication which originates near the middle of the valve.

Brachial valve less convex than the pedicle, its greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin, sloping with a gentle convex curvature to the antero-lateral margins, a little compressed towards the cardinal extremities; mesial fold narrow, defined to the beak, rounded, barely elevated above the general surface of the valve, smooth in all of the examples observed; lateral slopes marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are not shown on any of the specimens observed because of their condition of preservation, but a few concentric lines of growth are usually recognizable.

Remarks.—This species has only been observed in the form of internal casts and natural moulds of the exterior, in a fine-grained sandstone. In the internal casts the beak of the pedicle valve is always obtuse and more or less truncated, indicating a notable thickening of the shell in that region. A few natural moulds of the exterior have been observed, from which artificial casts of the beak and cardinal area have been secured, which show the external form of that portion of the shell. In the dimensions of the small, complete, internal cast given above, the length of the pedicle valve is materially less than it would be were the shell itself preserved. The total length of the other specimen whose dimensions are given is estimated from a cast from a natural mould of essentially the same size. The species is a very distinct one, but it more closely resembles *S. chouteauensis* than any other, it may be distinguished from that species, however, by the proportionately more elongate shell, the shallower and narrower mesial sinus which is either smooth or is marked only by an obscure mesial plication and never by lateral ones branching off from the inner margins of the bounding plications.

Horizon.—Kinderhook.

Brachythyris fernglenensis Weller

Plate LII, Figs. 5-11

1909. *Spirifer fernglensis* Weller, Bull. Geol. Soc. Amer., vol. 20, p. 306, pl. 13, figs. 9-10.

Description.—Shell small, wider than long, subglobular in form, hinge-line a little shorter than the greatest width of the shell, cardinal extremities rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 13.5 mm., length of brachial valve 11 mm., width 14.6 mm., length of hinge-line 13 mm., thickness 11 mm., width of mesial sinus in front 5.2 mm.

Pedicle valve strongly convex, the greatest convexity near or a little posterior to the middle, the umbonal region small, the surface curving rather abruptly both anteriorly, laterally and posteriorly from the point of greatest convexity; the beak small, rather short, incurved; cardinal area small and low, arched, the lateral margins usually not discernable, the surface of the area curving without demarkation into the lateral slopes of the valve, occasionally the lateral margins may be detected as a pair of faint ridges which slope from the beak to the cardinal extremities; the delthyrium broader than high, bordered on each side by a distinctly elevated ridge which passes from the apex to the hinge-line; lateral slopes strongly convex, as the surface approaches the lateral and anterior margins the curvature becomes more abrupt, until in adult shells it is nearly vertical to the plane of the valve, each marked by about 7 broad, depressed, rounded, more or less obscure, simple plications; mesial sinus narrow, shallow, rounded in the bottom, smooth, originating at the beak and slightly produced in front in a nasute extension nearly at right angles to the plane of the valve.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface curving more abruptly to the cardinal margin, sometimes a little depressed towards the cardinal extremities; mesial fold originating at the beak, smooth, rounded, but little elevated above the general surface posteriorly and only moderately elevated towards the front; lateral slopes marked by plications similar in form and number to those of the opposite valve, but somewhat stronger.

The minute surface markings are not clearly preserved on any of the specimens observed, but there is no indication of anything except concentric markings. More or less inconspicuous concentric growth lines are sometimes present.

Remarks.—This species is especially characterized by its rotund form. It differs from *S. chouteauensis* in its smaller size, greater convexity of the valves, smaller and less-defined cardinal area, the less extended beak of its pedicle valve, and the perfectly smooth fold and sinus. The largest example observed has a length of 15 mm.

Horizon.—Fern Glen formation of the Kinderhook.

Brachythyris chouteauensis Weller

Plate LVII, Figs. 4-11

1909. *Spirifer chouteauensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 305, pl. 13, fig. 11.

Description.—Shell suborbicular in outline, the length and width nearly equal, hinge-line about two-thirds the greatest width of the shell, cardinal extremities rounded. The dimensions of a nearly complete example are: length of pedicle valve 22 mm., length of brachial valve 20 mm., length

of hinge-line 13.5 mm., greatest width of shell, 24.5 mm., thickness 17 mm., height of cardinal area 2 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbo rather narrow, prominent, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the antero-lateral margins, sometimes a little compressed towards the cardinal extremities; beak small, sharply pointed, rather strongly incurved; cardinal area small, arched, the curvature becoming greater towards the beak, lateral margins more or less ill-defined, sloping from the beak to the cardinal extremities; lateral slopes convex antero-posteriorly, marked by from 8 to 11 simple, rounded plications; mesial sinus narrow, rather shallow, rounded in the bottom, well-defined to the beak posteriorly, becoming less well defined anteriorly, bounded by a pair of plications which are notably broader and stronger than those of the lateral slopes, marked by two or four obscure, depressed, rounded plications which originate from the inner margins of the bounding plications.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface curving abruptly to the cardinal margin, and more gently to the antero-lateral margins, usually somewhat compressed towards the cardinal extremities; mesial fold defined to the beak, convex, scarcely elevated above the general surface posteriorly, moderately elevated in front, obscurely marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell consist of obscure, exceedingly fine, concentric striæ which are ordinarily obliterated in the fossils. At irregular intervals several concentric lines of growth are usually present.

Remarks.—The plication of the fold and sinus of this species is very obscure, and not infrequently seems to be absent altogether at first sight. In its general form and proportions the species resembles *S. suborbicularis,* but it is always much smaller than the adult examples of that species. The cardinal area of the pedicle valve in *S. chouteauensis,* however, is proportionately smaller and less well defined than in *S. suborbicularis.* Members of this species have not infrequently been identified as *S. peculiaris,* but it differs conspicuously from that species in the lower and more defined cardinal area, the more approximate beaks of the two valves and in the obscure plications of the fold and sinus.

Horizon.—Kinderhook.

Brachythyris suborbicularis (Hall)

Plate LXI, Figs. 1-8; Plate LXII, Figs. 1-12

1858. *Spirifer suborbicularis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 644.
1875. *Spirifer suborbicularis* Meek and Worthen, Geol. Surv. Ill., vol. 6, p. 523, pl. 30, fig. 1.

Description.—Shell above medium size, suborbicular in outline, a little wider than long, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded or obtusely angular. The dimensions of a nearly complete, but small, undistorted specimen are: length 40 mm., width 46 mm., thickness 27 mm., length of hinge-line 32 mm. The dimensions of a large pedicle valve are: length approximately 56 mm., width 62 mm., convexity 23.5 mm., length of hinge-line 45 mm., height of cardinal area 6 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region rather narrow, the surface usually somewhat compressed towards the cardinal extremities; beak pointed and rather strongly incurved; cardinal area rather low, arched, the curvature becoming greater towards the beak, the lateral margins defined, sloping from the beak to the cardinal extremities with a slightly sigmoidal curve, the delthyrium rather large, wider than high, bordered on each side by a thickened ridge which is raised above the general level of the area; surface of the area marked by longitudinal lines of growth; lateral slopes of the valve each marked with 10 to 12 depressed, more or less obscure, simple plications, those near the sinus being broad, the successive ones towards the cardinal extremities becoming narrower and fainter, the last four or so becoming so faint, especially in large individuals, as to be almost obsolete; mesial sinus defined to the beak, anteriorly it becomes less sharply defined, is rather broad, of moderate depth, and rounded in the bottom, at the anterior margin it is sometimes produced into a nasute extension, it is marked in the median line by a narrow, ill-defined obscure or almost obsolete plication, and by one or two on each side which are broader but equally obscure.

Brachial valve less convex than the pedicle, its greatest convexity near the middle, the surface compressed towards the cardinal extremities, the beak projecting slightly beyond the hinge-line; mesial fold defined to the beak, where it is narrow and scarcely elevated, becoming broader and often rather strongly elevated towards the front, rounded in contour, marked by four or six very obscure, sometimes, apparently, almost or quite obsolete plications; lateral slopes marked by plications which are similar in number to those of the opposite valve, but which are commonly much more strongly developed.

The minute surface markings of the shell have not been clearly seen, but the shell seems to be smooth except for the presence of more or less strongly developed lines of growth.

Internally the muscular impressions of the pedicle valve are but faintly developed, and the dental plates are so short that they are represented in the internal casts as but slightly depressed grooves, one on each side of the delthyrium.

Remarks.—This species occurs somewhat commonly in the Burlington and Keokuk limestones, and has been identified by Beede from the Salem limestone of Indiana.[1] This last identification, however, is incorrect since the figure given to represent the species shows a shell with strong and elongate dental lamellæ. In general form the species somewhat resembles *S. subcardiiformis* and *S. gurleyi;* from the first of these it differs in its much longer cardinal area, and from both it differs in having much less strongly developed plications upon the lateral slopes, especially of the pedicle valve, and in the almost obsolete plications of the fold and sinus.

Horizon.—Burlington and Keokuk limestones.

Brachythyris subcardiiformis (Hall)

Plate LX, Figs. 1-15

1858. *Spirifer subcardiiformis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 660, pl. 23, figs. 6a-b.
1880. *Spirifer subcardiiformis* White, Cont. to Inv. Pal., No. 8, p. 165, pl. 41, figs. 2a-c.
1906. *Spirifer subcardiiformis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1313, pl. 21, figs. 2-2b.

Description.—Shell of medium size or larger, suborbicular in outline, the greatest width near the mid-length of the shell, the true hinge-line short, the cardinal extremities rounded. The dimensions of two individuals are: length 43 mm. and 28 mm., width 43.5 mm. and 32 mm., width of true cardinal area along the hinge-line 15.5 mm. and 10 mm., thickness 27.3 mm. and 17 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the anterior and lateral margins, the convexity of the valve extending to the cardinal extremities; beak pointed and incurved; cardinal area small, concave, becoming more curved towards the beak, sloping posteriorly at an angle of about 115 degrees to the plane of the valve, its width along the hinge-line about one-third the total width of the shell, the central half of its width occupied by the large triangular delthyrium so that the actual surface of the area is limited to two narrow bands which pass obliquely from the hinge-line on each side of the delthyrium to the beak, the lateral margins of the area are well defined and beyond them the surface of the valve is abruptly depressed into a concave, false cardinal area broader than the true area, which rounds

[1] *Spirifer suborbicularis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1312, pl. 19 figs. 3-3a; pl. 21, fig. 4. (1906.)

into the lateral slopes of the valve without any sharp line of demarcation; lateral slopes of the valve each bearing from 8 to 10 broadly rounded, simple plications which grow progressively smaller towards the cardinal extremities; mesial sinus originating at the beak where it is very narrow and well defined, anteriorly it becomes broad and shallow, flat or roundish in the bottom, and in large examples it is sometimes produced in a nasute extension anteriorly, it is usually occupied by three rounded plications of nearly equal size, similar to the larger plications upon the lateral slopes, all three plications originate near the beak, the two lateral ones originating from the inner margins of the lateral bounding plications a little in front of the origin of the median one, sometimes the number of plications is reduced to two in number and sometimes increased to four, but often when the number is abnormal they are not so nearly equal in size as in normal individuals.

Brachial valve less convex than the pedicle, its greatest convexity near the middle, the surface sometimes a little compressed towards the cardinal extremities, the beak projecting a little posteriorly from the hinge-line; mesial fold defined to the beak but scarcely elevated above the general surface of the valve, becoming gradually elevated to the front where it is rounded and of moderate height, in large individuals it is sometimes rather abruptly elevated near the anterior margin, in normal specimens it is marked by four, subequal, convex plications which originate from a single one at the beak, in individuals with more or less than three plications in the sinus of the pedicle valve there is a like variation in the fold of the brachial valve; lateral slopes of the valve bearing plications similar in form and number to those of the opposite valve.

Minute surface markings of the shell not observed, but concentric lines of growth of greater or less strength are usually present, which are sometimes crowded towards the anterior margin in large individuals.

Remarks.—This shell is a very characteristic member of the Salem fauna in Indiana and Illinois and has not been certainly seen from any other horizon, although some specimens are labeled as coming from the Keokuk limestone in Indiana. The shell is especially characterized by its very narrow cardinal area with the false area-like regions on either side of the true cardinal area. In general outline the shell resembles *S. suborbicularis,* but the plications are stronger in *S. subcardiiformis,* especially those of the fold and sinus.

Horizon.—Salem limestone.

Brachythyris gurleyi n. sp.

Plate LVIII, Figs. 4-8

Description.—Shell of medium size, suborbicular in outline, the greatest width near the mid-length of the shell, the cardinal extremities rounded.

The dimensions of a nearly complete individual are: length 30 mm., width 32 mm., length of hinge-line 20 mm., thickness 21 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, more gently to the anterior and lateral margins, the convexity extending to the cardinal extremities; beak pointed and incurved; cardinal area about two-thirds the total width of the shell, 5 mm. in height in the type, concave, becoming more curved towards the beak, its inferior portion sloping at an angle of about 115 degrees to the plane of the valve, its lateral margins defined, its surface marked by vertical striæ; delthyrium rather large, forming a nearly equilateral triangle; lateral slopes of the valve each bearing about 11 depressed, rounded plications, most of which are simple, although a tendency to divide is occasionally observable, they become progressively smaller towards the cardinal extremities; mesial sinus ill-defined, nearly or quite obsolete at the beak, shallow and rounded in the bottom, occupied by about 7 plications similar in strength to those upon the lateral slopes.

Brachial valve subelliptical in outline, a little less concave than the pedicle, its greatest convexity near the middle, the surface slightly compressed towards the cardinal extremities, the beak projecting a little posteriorly from the hinge-line; mesial fold scarcely defined at the beak, becoming moderately elevated anteriorly where it is rounded in contour and is not sharply differentiated from the lateral slopes, bearing eight plications, the four central ones being less distinct than the others, in the umbonal region the four central ones have become united into a single median plication and each pair of two lateral ones are also united so there are only three in all, and it is possible that these three also unite into a single one before reaching the beak, but the condition of preservation of the type is not such as to certainly show this; the lateral slopes of the valve bear plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell are not preserved in the type specimen, but a few rather weak concentric lines of growth are shown.

Remarks.—In general form and appearance this species resembles *S. subcardiiformis* and it has usually been so identified. It is easily distinguished from that species, however, by its much broader cardinal area and by the absence of the false cardinal area which is so conspicuous on that species, as well as by the less sharply defined mesial sinus with its larger number of plications and the occasional tendency of the plications to divide.

Horizon.—Salem limestone.

Brachythyris altonensis n. sp.

Plate LIX, Figs. 7-14

Description.—Shell small, subglobular in form, a little wider than long, the greatest width near the mid-length of the shell, the length of the hinge-line equal to about one-half the total width of the shell, the cardinal extremities rounded. The dimensions of two individuals are: length of pedicle valve 14.8 mm. and 14.5 mm., length of brachial valve 11 mm. and 10.8 mm., width 15.2 mm. and 15.5 mm., thickness 10.5 mm. and 9.8 mm., length of hinge-line 8.5 mm. and 9 mm., height of cardinal area 3 mm. and 2.8 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the convexity extending out to the cardinal extremities, umbo prominent, projecting posteriorly beyond the hinge-line, the surface sloping abruptly to the cardinal margin, more gently to the antero-lateral margins; beak pointed and incurved; cardinal area small, arched, broadly triangular in outline, the lateral margins defined, although the demarcation between the area and the lateral slopes of the valve is only slightly marked, sloping regularly from the beak to the cardinal extremities; the delthyrium large, its base occupying more than one-third the cardinal margin of the area; lateral slopes of the valve each bearing five simple, rounded plications which grow progressively smaller towards the cardinal extremities; mesial sinus distinct to the beak, rather shallow, flattened in the bottom anteriorly, marked along the median line by a narrow plication.

Brachial valve much less convex than the pedicle, the greatest convexity near or a little in front of the middle; mesial fold defined to the beak, bounded by furrows which are deeper and broader than those between the other plications, flattened on top and marked along the median line by a narrow and shallow groove; lateral slopes most convex towards the umbo, a little compressed towards the cardinal extremities, marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell have not been observed, but concentric lines of growth of variable strength are present which become more frequent towards the anterior margin.

Internally the dental lamellæ of the pedicle valve extend one-fifth or a little more from the beak towards the anterior margin with slight divergence, the muscular impressions are inconspicuous.

Remarks.—The types of this species are two nearly complete internal casts from a dolomitic layer of the St. Louis limestone near Alton. In recent collections the species occurs a few feet below the base of the brecciated layer of the formation, and the types doubtless came from this same position. If the specimens were differently preserved with the shell

substance present, it is possible that one or two additional plications might be present towards the cardinal extremities of each lateral slope of the valves. The state of preservation is also responsible for all absence of the minute surface characters of the shell. In its general aspect the species is similar to *S. suborbicularis* except in its much smaller size and in the distinct median plication of the fold.

Horizon.—St. Louis limestone.

Brachythyris semiplicata (Hall)

Plate LIX, Figs. 15-19

1860. *Spirifer semiplicata* Hall, 13th Rep. N. Y., State Cab. Nat. Hist., p. 111.

1866. *Spirifer cooperensis*, Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 155, pl. 14, figs. 5a-b.

Description.—Shell small, wider than long, the hinge-line a little shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete specimen are: length of pedicle valve 8.5 mm., length of brachial valve 7 mm., greatest width 9.1 mm., length of hinge-line 6 mm., thickness 6.4 mm.

Pedicle valve subpyramidal in form, the greatest depth posterior to the middle in the umbonal region, the surface curving abruptly to the cardinal margin on each side of the beak and more gently to the lateral and anterior margins, not compressed towards the cardinal extremities; beak blunt and short, incurved; cardinal area of moderate size, concave, its lateral margins not sharply defined, its surface curving into the lateral slopes of the valve with but slight interruption; mesial sinus originating as a flattening of the valve in the umbonal region, becoming broad anteriorly but remaining very shallow and flat, marked by a single low, rather faint, median plication, which originates near the middle of the valve; the lateral slopes rather sharply differentiated from the mesial sinus, each marked by about four simple, obscure, rounded plications which become obsolete a little past the middle of the valve.

Brachial valve depressed convex, much shallower than the pedicle, its greatest depth posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins, a little compressed towards the cardinal extremities; the beak obtuse, only slightly produced beyond the cardinal margin; the mesial fold obscure in the posterior half of the valve, broad, flat and only slightly elevated in front, marked by an obscure mesial furrow; the lateral slopes marked by obscure plications entirely similar to those of the opposite valve.

The finer surface markings consist of fine, concentric lines of growth upon each valve.

Remarks.—This species was originally described in a very inadequate manner without illustrations, from the Rockford limestone of Indiana, and the type seems to have been lost. The little shell which is illustrated herewith, and which has been used as a basis for the above definition, is from a limestone in Union County, Illinois, which is believed to be an extension of the Rockford limestone of Indiana. It seems to agree in all essential respects with Hall's original description of the species, and has consequently been so identified.

Horizon.—Rockford limestone of the Kinderhook.

Brachythyris peculiaris (Shumard)

Plate LVII, Fig. 12; Plate LVIII, Figs. 9-20; Plate LXXXIII, Figs. 3-5

1855. *Spirifer ? peculiaris* Shumard, Geol. Rep. Mo., 1855, p. 202, pl. C, figs. 7a-b.
1894. *Spirifera peculiaris* Keyes, Mo. Geol. Surv., vol. 5, p. 79.

Description.—Shell subrhomboidal in outline, usually wider than long, the greatest width at about the mid-length of the shell, the hinge-line about one-half as long as the greatest width, cardinal extremities rounded, the beaks of the two valves remote. The dimensions of two perfect individuals, one with average proportions, the other much more elongate than usual, are: length of pedicle valve 16.5 mm. and 18 mm., length of brachial valve 15 mm. and 16.5 mm., greatest width 19 mm. and 16 mm., length of hinge-line 9.5 mm. and 8 mm., thickness 14 mm. and 15 mm., height of cardinal area 4 mm. and 3.2 mm.

Pedicle valve strongly convex, the umbo prominent, the surface curving very abruptly to the cardinal margin and more gently to the antero-lateral margins; the beak acuminately pointed, rather small, strongly incurved; cardinal area rather high and narrow, the inferior portion directed in nearly a right angle to the plane of the valve, the upper portion strongly arched, the lateral margins sloping steeply from the beak to the extremities of the hinge-line, scarcely defined from the inflected parts of the lateral slopes which form a false cardinal area; each lateral slope divided into two regions by a rounded ridge which passes from the beak to the point of greatest lateral extension of the valve, on the posterior side of this ridge the surface is abruptly inflected and forms one side of a false cardinal area which is scarcely differentiated from the true cardinal area, the anterior slope on each side is marked by from 5 to 8 simple, depressed, rounded plications which terminate posteriorly along the rounded ridge between the anterior and posterior portions of the lateral slope; mesial sinus narrow, shallow, rounded in the bottom, continuing to the beak, without plications.

Brachial valve much less convex than the pedicle, the umbo prominent, the beak projecting conspicuously beyond the hinge-line posteriorly; the

mesial fold low, rounded, defined to the beak, smooth or sometimes faintly marked by a median furrow; lateral slopes convex, each divided into a posterior and an anterior portion by a rounded ridge passing from the beak to the point of greatest lateral extension of the shell, but the differentiation is not so strongly marked as in the pedicle valve, the posterior portion curves abruptly to the cardinal margin and is free from plications, the anterior portion curves more gently to the antero-lateral margin and is marked by plications similar in form and number to those of the opposite valve.

The minute surface markings of the shell consist of very fine concentric lines. Both valves also bear, at intervals, stronger concentric lines of growth which traverse both the anterior and posterior portions of the lateral slopes, and which terminate posteriorly in the pedicle valve at the lateral margins of the true cardinal area.

Remarks.—This shell is one of the most sharply defined species in all our Mississippian faunas and cannot be confused with any other. Examples of the shell here described as *S. chouteauensis* have sometimes been identified as *S. peculiaris*, but that species has much more approximate beaks with a longer hinge-line and lower cardinal area, and does not possess the conspicuous false cardinal area of *S. peculiaris*. The fold and sinus in the two species are also different in character. These same characters distinguish *S. peculiaris* from *S. burlingtonensis*, and in addition the more anterior position of the greatest width of the shell in *S. peculiaris*.

Horizon.—Chouteau limestone of the Kinderhook.

Genus *CYRTIA* Dalman

Description.—Shell small or of medium size, semipyramidal in form, the greatest width along the hinge-line, the sinus of the pedicle valve and the fold of the brachial valve well developed and non-plicate, the lateral slopes of the valves plicated or not. The pedicle valve with a very high cardinal area which may be flat or arched, the delthyrium narrowly triangular and covered by a transversely convex pseudodeltidium; internally the dental lamellæ are conspicuously developed and may reach anteriorly beyond the middle of the valve; no median septum present. Brachial valve as in *Spirifer*. Shell structure non-punctate.

Remarks.—The genus *Cyrtia* was originally established upon the species *C. exporrecta* from the Silurian of Sweden, and one or more species in the Silurian faunas of America are clearly congeneric with the genotype from Sweden. The characters which serve to differentiate the genus from *Spirifer* are its very high cardinal area, the strongly developed dental lamellæ and the pseudodeltidial covering of the delthyrium. In general form the members of the genus resemble *Cyrtina* more closely than *Spirifer*, but they lack the spondylium and median septum of that genus, as well as the punctate shell structure.

The species which is here recognized is based upon a single specimen of an incomplete pedicle valve which differs from the genotype in the greater development of the dental lamellæ, in the plicated lateral slopes of the valve and in the absence of the foramen through the pseudodeltidium. The specimen resembles the members of the genus *Pseudosyrinx* but lacks the delthyrial plate and the punctate shell structure, and possesses a convex pseudodeltidial covering of the delthyrium. It seems to agree with *Cyrtia* more closely than with any other genus, hence its reference to that genus in this place.

Cyrtia inexpectans n. sp.

Plate LXIII, Figs. 1-4

Description.—Shell of medium size, the hinge-line a little shorter than the greatest width of the shell, the cardinal extremities rounded. The species is known only from a single incomplete pedicle valve whose dimensions, so far as they can be determined, are: width along hinge-line 32 mm., height of cardinal area 14 mm., length of pedicle valve from beak to front margin +21 mm.

Pedicle valve subpyramidal in form, the surface sloping from the umbo to the lateral extremities in nearly straight lines which meet at the umbo in an angle of about 110 degrees, to the anterior margin the surface is gently convex; mesial sinus non-plicate, shallow, scarcely more than a median flattening of the valve; the beak pointed, curved so as to be directed at nearly a right angle to the cardinal area; cardinal area high, nearly flat below, becoming gently concave towards the apex beneath the beak, the lateral margins not sharply defined, the surface rounding into that of the lateral slopes; delthyrium narrowly triangular, at least twice as high as its width at the base, entirely covered by a convex pseudodeltidium through which there is no foramen; each lateral slope marked by 12 or 14 simple, depressed, radiating plications which originate along the cardinal margin and become very faint towards the cardinal extremities. Internally the dental lamellæ are strongly developed, extending anteriorly from the beak to the anterior margin of the shell so far as it is preserved, they diverge from the beak at an angle of about 26 degrees, nearly following the lateral margins of the mesial sinus; the muscular scars are only faintly marked and are not divided longitudinally by a median ridge or septum.

The surface markings of the shell, aside from the plications, so far as shown in the single specimen, consist of a few concentric lines of growth; so far as can be seen the shell structure is impunctate.

Remarks.—The specimen upon which this species is based is unique. It resembles some of the shells which have been described under the new genus *Pseudosyrinx*, especially *P. missouriensis*, but it differs from that

shell in the exceedingly elongate dental lamellæ, the very shallow mesial sinus and in the solid covering of the delthyrium by a pseudo-deltidium. The type specimen is an internal cast in chert, with the external mould, so that both the internal and external characters can be clearly seen. The internal cast shows an entire absence of any delthyrial plate such as is present in *Pseudosyrinx* and *Syringothyris*, joining the dental lamellæ transversely. The pseudo-deltidium is strong and rigid, and has not been destroyed in the least by fossilization; in the genus *Spirifer* this plate is exceedingly delicate and is rarely or never preserved, in *Syringothyris* and *Pseudosyrinx* it is more commonly present, but is always a thin, delicate plate which is much crumpled and crushed in fossilization when it is preserved at all, but in this species it was apparently as rigid and firm as any part of the shell. The absence of a foramen through the pseudo-deltidium is not an uncommon feature in *Cyrtia*. The absence of a punctate shell structure cannot be safely affirmed for the species from the observation of a single specimen, but in this example there is not the slightest indication of it. The combination of characters present in the specimen seems to indicate only the genus *Cyrtia*, to which genus the specimen is referred.

Horizon.—Residual chert, probably of Keokuk age.

Genus *SYRINGOTHYRIS* Winchell

Description.—Shells varying in size from small to very large, spiriferoid in form, with a much elevated cardinal area, the hinge-line straight and elongate, representing the greatest width of the shell, the fold and sinus well developed and usually non-plicate. The pedicle valve subsemi-pyramidal in form, the high cardinal area either flat, concave or convex, differentiated into three regions, a central including the delthyrium, and two lateral, by a pair of lines originating at the apex and passing obliquely to the cardinal margin, which they intersect at equal distances from the basal angles of the delthyrium; the central region is distinctly marked by vertical striæ, while the lateral regions are marked only by the horizontal lines of growth; internally the dental lamellæ are moderately well developed, they rest upon the floor of the valve and are a little produced anteriorly along the lateral margins of the muscular scar; they are united transversely by a delthyrial plate whose position is subparallel with the cardinal area but somewhat depressed below it; this plate extends to various distances from the apex of the delthyrium towards the hinge-line and at the middle point of its cardinal margin it is produced still further towards the cardinal margin of the valve as a free spine-like process; on the inner side of the spine-like extension of the delthyrial plate, and continuing along the median line of the inner surface of the plate towards the apex of the valve, is a tube which is

split longitudinally internally, this split tube, together with the extension of the delthyrial plate, being termed the syrinx. In some cases the syrinx is solid. A pseudodeltidial covering of the delthyrium entirely separate from the delthyrial plate and syrinx is sometimes present. The muscular scars as in *Spirifer*. The brachial valve essentially as in *Spirifer*, both externally and internally. Shell structure punctate throughout except in the central, vertically striated region of the cardinal area. The external surface covered with a minute, textile-like ornamentation except upon the central region of the cardinal area.

Remarks.—The genus *Syringothyris* represents a specialization of the *Spirifer* type which is characterized by the development of the syrinx, the punctate shell structure, the high cardinal area and the peculiar character of the minute surface ornamentation. Except the shell structure and the minute ornamentation of the shell, which frequently can not be recognized because of the condition of preservation, the distinguishing characters are confined to the pedicle valve, indeed, from the brachial valves alone not even the species can be successfully identified. The brachial valves differ from any of the corresponding valves of the Mississippian Spirifers, however, with which they might be confused, by reason of the absence of plications upon the fold and sinus.

Much has been written of the genus and its characters, have come to be firmly established. Much confusion still exists, however, among the species composing the genus, and in almost no case have the essential specific characters even been accurately pointed out. Schuchert[1] referred most of the Mississippi basin forms to these three species, *S. carteri, S. extenuatus,* and *S. textus,* considering no less than five other forms as synonyms under these three, but a careful investigation of a large amount of excellent material in which nearly every described form is well represented, besides some undescribed ones, has led the writer to the conclusion that most, if not all, the named species are good, although their really essential characters have not been clearly pointed out. In characterizing the species of the genus the brachial valves are of almost no value whatever, and when that valve alone is preserved for study, it is in most cases impossible to identify it. The essential specific characters are found in the pedicle valve and consist in the proportional height of the cardinal area, its degree of curvature, whether flat, concave, or convex, and especially in the size of the angle between the flatter portion of the area and the plane of the valve, this angle varying among different species from 25 to 110 degrees or more, but being fairly constant among different individuals of the same species. Another set of characters which seem to be of prime importance in specific differentiation are the char-

[1] 9th Ann. Rep. N. Y. State Geol., pp. 28-37. (1890.)

acters of the delthyrial plate and the syrinx. In all those species where a sufficient number of individuals have been observed showing these characters, they seem to be constant within reasonably narrow limits of variation, and they have been assumed to be of good specific value in other forms in which they have been observed sometimes in but a single individual; the different characteristics of this plate are shown in its transverse contour externally, whether flat, concave or longitudinally keeled, and in the length and width of the free extension of the syrinx.

The earliest described species of the genus were *S. textus* and *S. carteri*, both described by Hall as members of the genus *Spirifer* before the genus *Syringothyris* was established by Winchell. *S. textus* is a well-defined species, but *S. carteri* has always remained as more or less of an enigma, and several of our Mississippi basin forms have been identified with it on insufficient grounds; the true characters of the species still remain uncertain and in the present report it has not been recognized.

One reason for uncertainty in the identification of the various species of *Syringothyris* is that two distinct generic types have commonly been confused, the two types of shells being essentially alike in all respects except that one has a delthyrial plate with a well-developed syrinx upon its inner surface, while the other has the delthyrial plate with no indication of a syrinx. This latter group of shells has been defined as a new genus in this report and will be discussed later.

Syringothyris extenuatus (Hall)

Plate LXXII, Figs. 5-12

1858. *Spirifer extenuatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 520, pl. 7, fig. 6.
1890. *Syringothyris extenuata* Schuchert, 9th Ann. Rep. N. Y. State Geol. for 1899, p. 33 (in part).
1900. *Syringothyris extenuatus* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 77, pl. 1, figs. 1-3.

Description.—Shell of medium size, much wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly perfect pedicle valve are: length from beak to front margin 14 mm., height of cardinal area 19.4 mm., width along hinge-line 47 mm., width of sinus in front 10 mm. The dimensions of a nearly complete internal cast are: length of pedicle valve from beak to front margin 14 mm., length of brachial valve 13.2 mm., height of cardinal area 14.2 mm., width along hinge-line 40 mm., thickness 16.2 mm., width of sinus in front 10 mm.

Pedicle valve broadly subpyramidal in form, the surface sloping from the beak to the cardinal extremities in nearly straight lines, or with a slight convex or concave curvature, the lateral slopes very short from

front to beak, nearly straight or slightly convex from the cardinal to the front margins towards the central portion of the valve, becoming a little concave towards the cardinal extremities because of the slight vertical compression of the valve along the cardinal margin, the anterior slope along the median line nearly straight or slightly curved; mesial sinus narrow and rather sharply defined at the beak, becoming rapidly broader towards the front and much less well-defined, non-plicate, concave in the bottom and produced anteriorly in a broad, rounded, linguiform extension of moderate length; beak pointed, erect, rarely with a slight incurvature; cardinal area high, sloping posteriorly from the hinge-line at an angle of from 25 to 30 degrees to the plane of the valve, broadly triangular, the lateral margins sharply defined, the surface flat or very slightly convex, rarely with a very slight concavity just beneath the beak; delthyrium narrowly triangular, on each side of the delthyrium is a differentiated region bounded by lines which originate at the beak and diverge towards the hinge-line at a greater angle than the divergence of the margins of the delthyrium, the base of this broader triangle being nearly twice the width of the delthyrium at its base, the surface of this differentiated region is vertically marked while the remaining portion of the area is marked by transverse lines of growth; each lateral slope bearing about eighteen simple, depressed, radiating plications, which originate along the cardinal margin and become gradually finer and more obscure towards the cardinal extremities. Internally the dental plates are rather thick and widely diverging, and extend nearly or quite half way from the beak to the anterior margin of the valve on either side of the mesial sinus; the transverse, syrinx-bearing plate between the dental lamellæ extends between one-half and one-third the distance from the beak to the hinge-line, it is usually transversely concave externally or rarely with a slight median ridge towards its lower extremity, the free extension of the syrinx towards the hinge-line is very short, being no more than a median angular point from the margin of the transverse plate, the internal casts exhibit the characteristic split tube upon the inner surface of the transverse plate; muscular scars rather large, subovate in outline, not sharply defined on any of the specimens observed.

Brachial valve broadly subtriangular in outline, with the apex of the triangle in front truncated and emarginate, the surface convex throughout from the cardinal to the anterior margins, the curvature more abrupt to the cardinal margin, the greatest convexity at or near the anterior margin at the median line of the valve, the surface sloping from the median line to the cardinal extremities in a gently convex curve; mesial fold non-plicate, well-defined, narrow posteriorly and becoming rapidly broader towards the front; the beak short, scarcely extended beyond the hinge-line; cardinal area linear; each lateral slope marked by simple

plications similar in number to those of the opposite valve but somewhat stronger. Internally the cardinal process is broad and concave towards the front, on the floor of the valve a slight median ridge extends anteriorly from the cardinal process for about one-third the length of the valve; the muscular scars not well defined.

The minute surface markings are not shown upon the exfoliated specimens available for study, but the shell substance is minutely and closely punctate, the punctae are well developed not only upon the body of the shell but also upon the cardinal area except in the vertically marked, differentiated region lying on either side of the delthyrium.

Remarks.—This species was originally described from a brachial valve only, but more recent collections from the Chonopectus sandstone and the superjacent bed at Burlington, Iowa, have afforded an abundance of material which shows all of the essential characters of the species. It is a well-marked species characterized by its acutely angular cardinal extremities, the shortness of the pedicle valve from the beak to the anterior margin, this distance being shorter than or at least no longer than the height of the cardinal area, and by the small angle between the cardinal area and the plane of the valve. The species is not a large one, although it sometimes attains a somewhat greater size than the dimensions given, the largest specimen observed, a brachial valve, having a width of 64 mm. along the hinge-line. Occasional examples are slightly distorted or twisted towards the beak of the pedicle valve.

Horizon.—Chonopectus sandstone of the Kinderhook.

Syringothyris hannibalensis (Swallow)

Plate LXVIII, Figs. 1-7

1860. *Spirifer* (*Cyrtia?*) *Hannibalensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 647.
1890. *Syringothyris Carteri* Schuchert, 9th Ann. Rep. N. Y. State Geol., p. 30 (in part).
1895. *Syringothyris Hannibalensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 25, figs. 33-35.
1908. *Syringothyris hannibalensis* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 82, pl. 18, figs. 6-9; p. 88, pl. 19, figs. 4-5.

Description.—Shell rather large, much wider than long, the greatest width near the hinge-line, the cardinal extremities narrowly rounded. The dimensions of a nearly complete, exfoliated specimen are: length of pedicle valve from beak to front 30.5 mm., length of brachial valve 25.4 mm., width 51.5 mm., length of hinge-line 48 mm., height of cardinal area 16.3 mm., thickness 28 mm., width of sinus in front 17 mm., width of delthyrium at base 11.6 mm.

Pedicle valve subpyramidal in form, the surface sloping from the umbonal region to the cardinal extremities in nearly straight lines which

diverge at an angle of about 110 degrees, to the antero-lateral and anterior margins the surface slopes with a gently convex curvature; mesial sinus originating at the beak where it is sharply defined, rounded in the bottom and becoming broader and less sharply defined anteriorly, produced in front in a rounded lingual extension of moderate length; beak pointed, nearly erect or slightly incurved; cardinal area large, gently concave, the curvature becoming a little stronger towards the beak, sloping posteriorly from the hinge-line at an angle of from 60 to 65 degrees, the lateral margins rounding rather abruptly into the lateral slopes of the valve; delthyrium triangular, higher than wide, on each side of it is a vertically marked, differentiated portion of the cardinal area, bounded by lines diverging from each side of the beak at an angle greater than the divergence of the sides of the delthyrium, the base of the entire triangular area so formed being more than double the base of the delthyrium alone; each lateral slope bearing 20 or more simple, depressed, radiating, more or less obscure plications which originate along the cardinal margins and grow successively smaller towards the cardinal extremities. Internally the hinge-teeth are supported by rather strong dental plates which extend along the floor of the valve between one-third and one-half its length from the beak along the sides of the sinus, the divergence of the dental plates closely following the divergence of the margins of the sinus; the transverse, syrinx-bearing plate between the dental lamellæ bears a median longitudinal ridge externally and reaches about half way from the beak to the hinge-line, the free inward projecting point of the syrinx being rather broad, short and blunt; muscular scars of moderate size, with a distinct, median, longitudinal ridge.

Brachial valve subsemicircular in outline, emarginate at the middle anteriorly, the greatest convexity on the median line at or near the front, the surface curving more abruptly to the cardinal margin, depressed towards the cardinal extremities; mesial fold narrow and sharply defined posteriorly, becoming broader and less well-defined anteriorly, gradually elevated from nothing at the beak, rounded or somewhat flattened on top; the beak short, scarcely projecting beyond the cardinal margin, incurved; cardinal area narrow, lying in nearly the plane of the valve; each lateral slope marked by simple, rounded, plications, alternate with those of the opposite valve but much more strongly developed. Internally the cardinal process is broad and flat, marked with fine vertical ribs and grooves, the crural plates are strong and diverge from either side of the cardinal process with the dental sockets excavated from their outer surfaces; the muscular scars are not strongly defined, divided longitudinally by a low, median ridge, which extends from the beak for two-thirds the length of the valve.

The minute surface markings of the shell consist of concentric series of exceedingly fine and narrow, subrhomboidal depressions which are deeper at their proximal or posterior extremities, these depressions being arranged alternately in succeeding rows. Rather strong concentric lines of growth are present upon all non-exfoliated specimens, which are of varying degrees of strength and are irregularly distributed from the beak to the front. Shell structure punctate.

Remarks.—This is one of the forms which Schuchert has made synonymous with *S. carteri,* but it is undoubtedly a well characterized species, and so far as known is confined to the fauna of the Louisiana limestone.

Horizon.—Louisiana limestone of the Kinderhook.

Syringothyris halli Winchell

Plate LXXII, Figs. 13-23

1863. *Syringothyris Halli* Winchell, Proc. Acad. Nat. Sci. Phil., p. 8.
1901. *Syringothyris halli* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 158, pl. 13, figs. 1-3.

Description.—Shell below medium size, much broader than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of a nearly complete example are: length of pedicle valve from beak to front margin 12.8 mm., length of brachial valve 12.2 mm., height of cardinal area 10.9 mm., width along hinge-line 30.6 mm., thickness 13 mm., width of sinus in front 7.2 mm.

Pedicle valve subpyramidal in form, the surface sloping from the beak to the cardinal extremities and to the anterior margin in nearly straight lines or with but slight curvature; the mesial sinus of moderate depth, rounded in the bottom, rather sharply defined throughout, originating at the beak and increasing in width regularly to the front, produced anteriorly in a rather short, rounded, lingual extension; beak pointed, erect, or very slightly incurved; cardinal area high, sloping posteriorly from the hinge-line at an angle of from 50 to 60 degrees to the plane of the valve, broadly triangular in outline, flat or slightly concave, the lateral margins sharply defined; delthyrium narrowly triangular, the height about one and one-half the width; each lateral slope bearing about 16 simple, depressed plications which originate along the cardinal margin and grow successively finer towards the cardinal extremities. Internally the dental lamellæ are well developed, diverging from the beak at a wider angle than the sides of the mesial sinus, and extending nearly one-half the length of the shell from the beak to the front margin on each side of the sinus; the transverse plate between the dental lamellæ reaches less than half way from the beak to the hinge-line, its external surface is marked by a distinct, longitudinal, median ridge

which is produced below in the free tube of the syrinx whose length is not determined; muscular scars not well defined on the specimens studied.

Brachial valve shallower than the pedicle, its greatest depth near the front margin at the median line, the surface curving more abruptly to the cardinal margin, somewhat compressed towards the cardinal extremities; mesial fold distinctly elevated to the beak, well defined, of moderate height, rounded on top; the beak very short and but slightly projecting beyond the cardinal margin; cardinal area linear; each lateral slope marked by simple plications similar to those of the opposite valve but somewhat stronger.

The minute surface markings of the shell are not well shown upon any of the specimens studied, but concentric lines of growth of variable strength are usually present towards the front margin. Shell substance punctate.

Remarks.—This species was considered as a synonym of *S. extenuatus* by Schuchert in his discussion of the genus *Syringothyris*,[1] and Winchell evidently included specimens which must be identified as *S. extenuatus* in his *S. halli*. The type specimens of the species, however, in the University of Michigan collection, are from bed No. 4, of the Kinderhook, at Burlington, Iowa, and all of the specimens which have been observed by the writer are from the same formation and locality. Specimens of *S. extenuatus* in the University of Michigan collection were labeled by Winchell as *S. halli* var., showing that he recognized a difference between them. The two species are entirely distinct, with no intermediate variations, and can be easily distinguished. *S. halli* is a smaller shell, less extended along the hinge-line, proportionally longer from the beak of the pedicle valve to the front margin as compared with the height of the cardinal area, with a much more sharply defined mesial sinus towards the front of the pedicle valve, with the transverse syrinx-bearing plate between the dental lamellæ, with a distinct median longitudinal ridge, and with the angle between the cardinal area and the plane of the valve much greater. The general proportions of the shell are more nearly those of *S. hannibalensis*, but it is a much smaller and proportionally shorter species than that.

Horizon.—Kinderhook.

Syringothyris bushbergensis n. sp.

Plate LXXIII, Figs. 8-10

Description.—Shell above medium size, wider than long, the greatest width near or on the hinge-line, the cardinal extremities rounded or subrectangular. The dimensions of a large pedicle valve are: length from

[1] 9th Ann. Rep. N. Y. State Geol., p. 33. (1890.)

beak to front margin 28 mm., height of cardinal area 24 mm., greatest width 40 mm., length of hinge-line 36.8 mm., width of sinus in front 14 mm., width of delthyrium at hinge-line 10.5 mm.

Pedicle valve subpyramidal in form, the surface sloping from the umbo to the lateral and anterior margins with a gently convex curvature, the surface of the lateral slopes rounding towards the lateral margins of the cardinal area as they approach the cardinal extremities, but distinctly differentiated from the area; mesial sinus non-plicate, shallow, rounded in the bottom, narrow and sharply defined at the beak, becoming broad and less sharply defined anteriorly; beak erect; cardinal area flat, sloping anteriorly from the hinge-line at an angle of about 40 degrees to the plane of the valve, the lateral margins sharply defined; delthyrium narrowly triangular, its height twice or more than twice its width at the base; each lateral slope marked by 14 or more simple, depressed, radiating plications which originate near the cardinal margin and become faint or nearly obsolete towards the cardinal extremities where the surface curves towards the cardinal area. Internally the dental lamellæ are rather short and somewhat thickened, their divergence being a little greater than that of the sides of the mesial sinus; the muscular scars are rather strongly impressed in the older specimens, and are short, subovate in outline, with a distinct, median, longitudinal ridge; the delthyrial plate extends less than half way from the apex of the delthyrium to the hinge-line, it is convex transversely on its outer surface or is marked by a rather broad, rounded, median, longitudinal elevation whose sides slope to the lateral margins of the plates, the free extension of the syrinx is apparently short.

The minute surface markings of the shell are not capable of preservation in the medium in which the specimens occur, but a few inconspicuous, concentric lines of growth are present upon most of the specimens.

Remarks.—This species is established upon several specimens of pedicle valves preserved as internal casts and external moulds in a friable sandstone. It resembles *S. extenuatus* in some respects, but has a greater angle between the cardinal area and the plane of the valve, a relatively higher area, and the cardinal extremities are nearly rectangular or rounded instead of extending into acutely angular points. It differs from *S. platypleurus* in its somewhat lower cardinal area and the rounded or quadrangular cardinal extremities, and in the broad, transverse convexity of the delthyrial plate instead of the subquadrangular, elevated, longitudinal, median rib. It is not at all similar to any of the other species with flat cardinal area and can be distinguished from others by the proportions and flatness of the cardinal area.

Horizon.—Bushberg sandstone of the Kinderhook.

Syringothyris missouri Hall

Plate LXX, Figs. 6-15

1894. *Syringothyris Missouri* Hall, 13th Ann. Rep. N. Y. State Geol., p. 650.
1895. *Syringothyris Missouri* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, p. 363, pl, 39, figs. 29-31.
1897. *Syringothyris Missouri* Hall, 14th Ann. Rep. N. Y. State Geol., p. 358, pl. 8, figs. 14-16.

Description.—Shell small, with very high cardinal area, wider than long, the greatest width a little in front of the hinge-line, the cardinal extremities rounded. The dimensions of two specimens, the larger one the holotype of the species, are: length of pedicle valve from beak to front margin 14.8 mm. and 13.5 mm., length of brachial valve 11.5 mm. and 10.9 mm., height of cardinal area 10 mm. and 9 mm., maximum width of shell 20 mm. and 18.5 mm., length of hinge-line 17 mm. and 14 mm., thickness 15 mm. and 13.5 mm., width of sinus in front 6 mm. and 5.2 mm.

Pedicle valve subpyramidal in form, the surface sloping steeply from the umbo to the lateral and anterior margins with a slightly convex curve or with almost no curvature; the mesial sinus originating at the beak, shallow, non-plicate, rounded in the bottom, and rather sharply defined, produced in front in a short, rounded extension; beak small, a little curved; cardinal area very high, nearly flat, except close to the apex where it is a little arched, the lateral margins ill-defined, the surface rounding into the lateral slopes; delthyrium narrowly triangular, much higher than wide, the point of the syrinx extending two-thirds the distance from the apex to the hinge-line; each lateral slope marked by from eight to ten simple, depressed, radiating plications which grow successively smaller towards the cardinal extremities. Internally the dental plates are thin and well-developed, sometimes extending nearly half-way from the beak to the front margin along the floor of the valve; the character of the muscular scars is not clear in any of the specimens studied; the outer surface of the transverse, syrinx-bearing plate, between the dental lamellæ is distinctly marked by a longitudinal median rib which is extended in the free, spine-like portion of the syrinx towards the hinge-line.

Brachial valve moderately convex, a little compressed towards the cardinal extremities, the surface curving more abruptly to the cardinal margin; mesial fold originating at the beak, low, rounded on top, sharply defined; beak short, extending a little beyond the hinge-line, incurved; the cardinal area very narrow.

External surface of the shell not preserved on any of the specimens examined, but the surface of the exfoliated shells shows that the shell substance was punctate.

Remarks.—This is the smallest of our species of *Syringothyris* and is characterized by its relatively high and nearly flat cardinal area, whose surface rounds into the lateral slopes of the valve without any sharp line of demarcation. The anterior extension of the dental plates of the pedicle valve to nearly the middle of the valve is another somewhat unusual character.

Horizon.—Chouteau limestone of the Kinderhook.

Syringothyris newarkensis n. sp.

Plate LXVIII, Figs. 8-15

Description.—Shell above medium size, greatest width along the hinge-line which is usually greatly extended, the cardinal extremities acutely angular. The dimensions of a partially restored specimen are: length of pedicle valve 31 mm., length of brachial valve 19 mm., greatest width ±58 mm., thickness 30.5 mm., height of cardinal area 23 mm., width of sinus in front 13 mm., width of delthyrium at base 10 mm.

Pedicle valve subpyramidal in form, the surface sloping with a gently convex curvature from the umbo to the lateral and anterior margins, or sometimes slightly concave from the umbo to the cardinal extremities; mesial sinus non-plicate, originating at the beak, of moderate width and depth, rounded in the bottom, a little produced in front in a rounded extension; beak pointed, a little incurved; cardinal area high, gently concave with the curvature increasing towards the beak, the lateral margins sharply defined, the surface sloping anteriorly from the hinge-line, the lower and flatter portion lying at an angle of about 60 degrees to the plane of the valve; the vertically marked secondary area well defined when the surface of the shell is well preserved, each section at the cardinal margin being about equal to the width of the delthyrium at its base; delthyrium rather narrow, its width at the base being about two-fifths its height. Surface of each lateral slope marked by from 18 to 20 simple, depressed, radiating plications, which originate along the cardinal margin, growing successively smaller towards the cardinal extremities. Internally the dental lamellæ extend anteriorly from the beak for somewhat more than one-third the length of the valve; the delthyrial plate is moderately depressed below the surface of the cardinal area and is marked by a distinct longitudinal rib which is produced notably beyond the margin of the plate as a free extension of the syrinx.

Brachial valve emarginate in front, most convex between the middle and the anterior margin on the median line, the surface curving more abruptly to the cardinal margin, compressed towards the cardinal extremities; mesial fold well developed, originating at the beak, non-plicate, rounded or slightly flattened on top; beak short and somewhat incurved, projecting a little beyond the cardinal margin. Surface of each lateral

slope marked by simple, depressed, rounded, radiating plications, similar in number to those of the opposite valve, but marked off by more strongly impressed radiating furrows.

The minute surface markings of the shell are not well preserved upon any specimen observed, but the characteristic markings of the genus are suggested at several points, and the punctate structure of the shell is clearly shown.

Remarks.—This species is perhaps most closely related to *S. typa,* but it is a smaller shell, more extended along its cardinal line in its normal condition, with relatively much shorter brachial valve which is much more compressed towards the cardinal extremities. In the pedicle valve the delthyrium is much more narrowly triangular than in *S. typa,* and the mesial sinus is narrower. One specimen studied is less extended along the hinge-line than usual, and has more nearly the form of *S. typa,* but it is a distorted example, showing that it must have lived under abnormal conditions, but even this specimen has a much more narrowly triangular delthyrium and is more compressed towards the cardinal extremities of the brachial valve than *S. typa.* Two other species of the genus which have essentially the same angle of divergence between the cardinal area and the plane of the valve, are *S. hannibalensis* and *S. halli,* but each of these species has a proportionally lower cardinal area and a more broadly triangular delthyrium.

Horizon.—Kinderhook.

Syringothyris typus Winchell

Plate LXIX, Figs. 1-5

1863. *Syringothyris typa* Winchell, Proc. Acad. Nat. Sci. Phil., p. 7.
1886. *Syringothyris typus* Winchell, Geological Studies or Elements of Geology, p. 236, figs. 181-182.
1890. *Syringothyris Carteri* Schuchert, 9th Ann. Rep. N. Y. State Geol., p. 30 (in part).
1894. *Syringothyris typa* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 30, figs. 1-2.
1895. *Syringothyris typa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 26, figs. 6, 7, 10; pl. 27, figs. 1-3.

Description.—Shell large, broader than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly complete but somewhat distorted specimen are: length of pedicle valve from beak to front 47 mm., length of brachial valve, approximately 40 mm., width along hinge-line 68.5 mm., height of cardinal area 26 mm., thickness approximately 42 mm., width of sinus in front 28 mm., width of delthyrium at base 16 mm.

Pedicle valve subpyramidal in form, the surface sloping with a gently convex curvature from the umbo to the lateral and anterior margins; mesial sinus non-plicate, originating at the beak where it is rather well

defined, becoming broader and less well defined toward the front, rounded in the bottom and produced anteriorly in a moderately long, rounded, lingual extension; beak pointed, a little incurved; cardinal area high, gently concave with the curvature increasing towards the beak, sloping anteriorly from the hinge-line so that the lower and flatter portion lies at an angle of about 55 degrees to the plane of the valve in the specimen whose dimensions are given above, the triangular, differentiated, vertically marked portion of the area lying on each side of the delthyrium is large, the lateral basal angles of this larger triangle lying nearly half way from the basal angles of the delthyrium to the cardinal extremities; delthyrium rather broad, its width between two-thirds and one-half its height; each lateral slope is marked by from 20 to 24 simple, depressed plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities, the last two or three or more being almost obsolete. Internally the length of the dental lamellæ in the bottom of the valve but has not been observed, the delthyrial plate is concave transversely with a slight, median, longitudinal ridge, and extends about half way from the apex of the delthyrium to the hinge-line, the free extension of the syrinx is rather broad and is about one-third the length of the fixed delthyrial plate.

Brachial valve most convex on the mesial line at or near the anterior margin, the surface curving most abruptly to the cardinal margin, somewhat impressed towards the cardinal extremities; mesial fold well developed, rounded on top, non-plicate; beak short, incurved, projecting slightly beyond the cardinal margin; cardinal area narrow, lying in nearly the plane of the valve; each lateral slope marked by simple, rounded plications, similar in number to those of the opposite valve but more strongly developed.

The minute surface markings of the shell are not shown on the partially exfoliated specimens examined, but a few small patches are sufficiently well preserved to show that the characteristic "twilled cloth" markings were present. Concentric lines of growth of greater or less strength are commonly distributed irregularly upon both valves. Shell structure minutely punctate.

Remarks.—This species, the type of the genus, has sometimes been considered as a synonym of *S. carteri*, a species which is imperfectly known, the types of that species being brachial valves which do not exhibit the specific or even the generic characters.

Two groups of spiriferoid shells with greatly elevated cardinal areas are present in the Mississippian faunas, both of which are characterized by the peculiar "twilled cloth" surface markings, the punctate shell structure and usually by the non-plicate fold and sinus. The distinction between the two groups is found in the presence or absence of the syrinx

upon the transverse delthyrial plate joining the dental lamellæ. The group of shells from which the syrinx is lacking includes several distinct specific forms from various horizons, and is described as a new genus (*Pseudosyrinx*) in the present report. Among the Waverly specimens commonly referred to *S. carteri*, examples preserving the delthyrial characters are rare, but among them both syrinx-bearing shells and others without the syrinx have been observed, and as it seems to be impossible to determine surely what *S. carteri* really is, the name should be dropped. *S. typa* differs from *S. hannibalensis* in its larger size, its proportionally higher cardinal area, in its more deeply placed and transversely concave delthyrial plate, and much longer free extension of the syrinx. From the European *S. cuspidatus* with which it has sometimes been compared, *S typa* differs in its lower cardinal area, which is concave instead of more or less strongly convex, in the symmetrical or nearly symmetrical beak of the pedicle valve instead of the more or less strongly twisted beak of *S. cuspidatus*, and in the very different condition of the syrinx, the free portion of which is exceedingly elongate and slender in the European species.

Horizon.—Upper Kinderhook.

Syringothyris platypleurus n. sp.

Plate LXXII, Figs. 1-4

Description.—Shell rather large, wider than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of the holotype are: length of pedicle valve from beak to front 34.5 mm., length of brachial valve 23 mm., width 60 mm., height of cardinal area 38.5 mm., thickness 41.8 mm., width of sinus in front 17 mm., width of delthyrium at hinge-line 13 mm.

Pedicle valve subpyramidal in form, the surface sloping in nearly straight lines to the cardinal extremities, the lateral and anterior margins slightly compressed vertically towards the cardinal extremities; mesial sinus shallow, rounded in the bottom, not sharply defined; the beak erect, pointed; cardinal area very high, nearly flat, its lateral margins sharply defined, sloping anteriorly from hinge-line at an angle of about 40 degrees to the plane of the valve, the triangular, vertically marked, differentiated region lying on each side of the delthyrium with a width at its base a little less than one-half the length of the hinge-line; delthyrium narrowly triangular, nearly three times as high as wide; each lateral slope marked by about 20 rather faint, depressed plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities. Internally the dental lamellæ extend more than half way from the beak to the anterior margin at the sides of the sinus along the floor of the valve, their angle of divergence being essen-

tially the same as the lateral boundaries of the sinus; the transverse delthyrial plate extends about two-fifths the distance from the apex of the delthyrium to the hinge-line, with the slender, free extension of the syrinx continuing at least one-half as far again, on its outer side the delthyrial plate is flat on either side, with a narrow, squarely elevated median, longitudinal ridge, which continues into the free portion of the syrinx; the muscular scars are narrow and not deeply impressed, and are divided longitudinally by a slight median ridge.

Brachial valve moderately convex, subsemicirenlar in outline, with a regularly rounded emargination in front occupying the width of the mesial fold, the surface curving more abruptly to the cardinal margin, compressed towards the cardinal extremities; mesial fold of moderate height, rounded on top, well defined towards the beak, becoming less well defined anteriorly; each lateral slope marked by about 20 simple, depressed, rounded, radiating plications, similar to those of the opposite valve but more strongly defined. Internally the muscular scars are not strongly impressed, they are divided longitudinally by a low median ridge which extends more than half way from the beak to the anterior margin.

The minute surface markings and punctate shell structure are not preserved upon the holotype of this species, this specimen being for the most part an internal cast, the parts of the shell which are preserved being entirely silicified and not preserving their markings. Several concentric lines of growth are shown upon the specimen.

Remarks.—This species is characterized by its proportionally high area and the very oblique anterior slope of the area from the hinge-line. In the small angle between the cardinal area and the plane of the valve, in the shortness of the pedicle valve from beak to front as compared with the height of the cardinal area, and in the slight vertical compression of the pedicle valve towards the cardinal extremities, this species resembles *S. extenuatus.* It is fundamentally different from *S. extenuatus,* however, in its proportionally much higher cardinal area and in the form of the delthyrial plate and syrinx. The species differs from *S. typa* in its flat and more posteriorly sloping cardinal area, and in the form of the delthyrial plate and syrinx. In some respects this shell approaches more closely to the European *S. cuspidatus* than any other of the American species, the flat delthyrial plate with its squarish, median, longitudinal ridge externally, which is produced in the slender free syrinx, being similar in the two species, but the free syrinx is much more elongate in *S. cuspidatus;* in *S. platypleurus,* however, the cardinal area is not convex, the beak is not distorted, and the anterior slope of the area is much greater.

A specimen from the lower Burlington limestone at Osceola, Missouri, has been referred to this species. It shows only a portion of the in-

ternal surface of the cardinal area, including a considerable portion of the delthyrial plate with the syrinx well preserved. This specimen had a very high and flat cardinal area with a narrowly triangular delthyrium, the proportions so far as preserved being essentially the same as in the type of *S. platypleurus*, the only important difference between it and the type of the species, so far as can be seen, is in the apparently perfectly flat external surface of the delthyrial plate, the longitudinal, squarish ridge being absent.

A small specimen from Louisiana, Missouri, with an approximate width of 28 mm. along the hinge-line, when completed, agrees well with the type of the species in the slope of the cardinal area and in the characters of the delthyrial plate, but the area is proportionally lower and is very slightly arched just under the beak, the number of plications is smaller, which may well be due to the smaller size of the shell, and there are very faint indications of several obscure plications in the mesial sinus. This specimen preserves the minute surface characters which consist of series of minute papillæ arranged in quincunx, giving the surface the peculiar "twilled cloth" appearance so characteristic of the genus, and the punctate structure of the shell is indicated.

Horizon.—Burlington limestone.

Syringothyris textus (Hall)

Plate LXIX, Figs. 6-9; Plate LXX, Figs. 1-4; Plate LXXI, Figs. 1-2

1857. *Spirifer textus* Hall, 10th Rep. N. Y. State Cab. Nat. Hist., p. 169.
1875. *Spirifer Carteri* Meek, Pal. Ohio, vol. 2, p. 285, pl. 14, figs. 7a-d.
1881. *Spirifer textus* White, 2nd Ann. Rep. Dep. Stat. and Geol. Ind., p. 512, pl. 7, figs. 1-2.
1890. *Syringothyris texta* Schuchert, 9th Ann. Rep. N. Y. State Geol., p. 34.
1894. *Syringothyris texta* Hall and Clarke. Int. to Study of Brach., pt. 2, pl. 30, figs. 4-9.
1894. *Syringothyris texta* Keyes, Mo. Geol. Surv., vol. 5, p. 88.
1895. *Syringothyris texta* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 26, figs. 9, 12; pl. 27, figs. 4-12.

Description.—Shell large, much broader than long, the greatest width along the hinge-line, the cardinal extremities angular. The dimensions of a nearly perfect specimen of about average size are: length of pedicle valve from beak to front margin 43.6 mm., length of brachial valve 34.5 mm., height of cardinal area 28 mm., width along the hinge-line 95 mm., thickness 43 mm., width of mesial sinus in front 25 mm., width of delthyrium at hinge-line 18 mm.

Pedicle valve subpyramidal in form, the surface sloping from the beak to the antero-lateral margins with a gently convex curve, from the beak to the anterior margin along the median line the slope is also gently con-

vex but is much more abrupt; mesial sinus non-plicate, originating at the beak, it is narrow and rather sharply defined in the umbonal region, becoming broader and less sharply defined anteriorly, deep and rounded in the bottom, produced in front in a rounded lingual extension; beak obtusely pointed, usually nearly erect but sometimes a little incurved; cardinal area high and usually nearly flat, sometimes moderately arched towards the beak, the entire surface in those specimens with a flat area, and the lower, flatter portion in those becoming concave towards the beak, slopes anteriorly from the hinge-line at an average angle of 58 degrees in 12 specimens, the lateral margins sharply defined, usually sloping from the beak to the cardinal extremities with a gently convex curvature which becomes a little more abrupt as it approaches the cardinal extremities; delthyrium large, broadly triangular, higher than wide, covered by a pseudodeltidium which is usually destroyed; each lateral slope marked by from 18 to 24 simple, depressed, rounded plications which originate along the cardinal margin. Internally the dental plates are short and rather thick, the continuous portion of the transverse syrinx-bearing plate connecting them is flat externally and extends one-third or less than one-third of the distance from the beak to the hinge-line, with the free, median, spine-like, tubular projection sharply differentiated from the apical portion, more or less trifid at its termination, and reaching to a point beyond the middle of the distance from the beak to the hinge-line; muscular scars strong and well-defined, subovate in outline, the adductor scars narrow and elongate, occupying a rather sharply depressed area along the median line of the valve, the diductor scars on either side much larger and marked by numerous branching grooves and ridges which tend to radiate in all directions from the lateral margins of the adductor scars.

Brachial valve strongly convex, its depth sometimes nearly or quite equal to that of the pedicle valve, the surface convex from the cardinal to the antero-lateral and anterior margins, with the curvature more abrupt to the cardinal margin, towards the cardinal extremities the surface usually becomes somewhat compressed; the rounded, non-plicate mesial sinus is depressed towards the beak, becoming much higher and less sharply defined anteriorly; cardinal area narrow and inconspicuous; beak short, incurved, but little extended beyond the cardinal margin; the plications of the lateral slopes entirely similar to those of the opposite valve and alternate with them. Internally the cardinal process is broad and flat, with a short median thickening of the interior of the valve in front of its base, its surface of muscular attachment marked by numerous, fine, vertical, angular grooves and ridges; the crural plates are thick and strong, with rather small dental sockets excavated in their outer margins; the muscular scars large, reaching more than half-way to the anterior

margin of the valve, not deeply impressed, extending laterally beyond the limits of the mesial fold posteriorly, but confined within the limits of the fold anteriorly, marked by a slight median depression which is sometimes scarcely noticeable.

Remarks.—This is perhaps the best known species of *Syringothyris,* being especially abundant in some of the Knobstone beds of southern Indiana. It is characterized by the great width and the comparatively low and nearly flat cardinal area. Schuchert[1] has considered both *S. subcuspidatus* and *S. propinquus* as synonyms of *S. texta,* but *S. subcuspidatus* is certainly distinct from it and perhaps also *S. propinquus.* The distinguishing characteristics of these species will be discussed under the descriptions of these forms.

Horizon.—Keokuk limestone and Knobstone formation.

Syringothyris subcuspidatus (Hall)

Plate LXXI, Figs. 3-7

1858. *Spirifer subcuspidatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 646, pl. 20, figs. 6a-b.

1894. *Syringothyris subcuspidata* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 30, fig. 3.

1895. *Syringothyris subcuspidatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 26, figs. 8, 11; pl. 27, fig. 18.

Description.—Shell large, wider than long, the greatest width at the hinge-line, the cardinal extremities usually sub-rectangular. The dimensions of a nearly complete specimen are: length of pedicle valve from beak to front 53.5 mm., length of brachial valve 40.3 mm., width 66 mm., height of cardinal area 18.6 mm., thickness 42 mm., width of sinus in front 26.2 mm., width of delthyrium at base 12 mm.

Pedicle valve strongly convex, most prominent on the umbo, the surface sloping to the cardinal extremities with a gently convex curvature, and with a greater curvature to the antero-lateral and anterior margins; mesial sinus of moderate depth, rounded in the bottom, originating at the beak where it is narrow and sharply defined, becoming broader and less sharply defined anteriorly, produced in front in a rounded lingual extension; the beak nearly erect or a little incurved, sometimes slightly unsymmetrical or twisted; cardinal area rather high, broadly triangular, nearly flat or gently concave, sloping posteriorly from the hinge-line, the inferior portion lying at an angle of about 95 degrees to the plane of the valve, the differentiated, vertically marked region lying on either side of the delthyrium is very broad, the base of the triangle being more than one-half of the total length of the hinge-line; delthyrium broad, its width

[1] 9th Ann. Rep. N. Y. State Geol., p. 34. (1890.)

at the base being two-thirds or more of the height; each lateral slope marked by from 18 to 20 simple, depressed, rounded plications which are nearly or quite as strong as those of the opposite valve, they originate along the cardinal margin and grow successively smaller towards the cardinal extremities. Internally the dental lamellæ are well developed and rather thick, they extend anteriorly along the floor of the valve for nearly one-half the distance from the beak to the antero-lateral margins, diverging from the beak at an angle much greater than the lateral margins of the mesial sinus; the muscular scars large and broad, reaching more than half way from the beak to the front of the shell, divided along the median line from the beak nearly to the middle of the scar by a low median ridge or septum; the delthyrial plate between the dental lamellæ reaches about half way from the apex of the delthyrium to the hinge-line, with the free part of the syrinx extending still further downward, it is distinctly keeled longitudinally along the median line, the keel extending out into the free part of the syrinx.

Brachial valve sometimes nearly or quite as convex as the pedicle, its greatest convexity on the median line at the front of the valve, the surface curving more abruptly to the cardinal margin and becoming more or less compressed towards the cardinal extremities; mesial fold sharply defined to the beak where it is narrow and scarcely elevated above the general surface of the valve, becoming broader and higher anteriorly and rounded on top; beak short, incurved, the umbonal region projecting somewhat beyond the cardinal margin; cardinal area narrow, lying nearly in the plane of the valve; each lateral slope marked by 18 or 20 simple plications similar to, but sometimes a little stronger than, those of the opposite valve.

The minute surface markings are not commonly fully preserved upon the more or less exfoliated specimens of this species, but they are sufficiently well preserved in patches to indicate that they are of the typical "twilled cloth" character which is common to the genus. The punctate structure of the shell is also commonly obliterated and has not been observed in any of the specimens studied, but it was doubtless present in the living shell. Concentric lines of growth are commonly present upon the shells, they are irregularly arranged and of varying strength, some of them usually being conspicuous.

Remarks.—This species has been considered as a synonym of *S. textus* by Schuchert,[1] but the two forms are clearly distinct in several important respects. *S. subcuspidatus* is commonly a narrower shell with proportionally lower cardinal area, which is usually moderately concave instead of flat; a more important difference is in the position of the cardinal area which slopes posteriorly from the hinge-line, making an obtuse angle with the

1 9th Ann. Rep. N. Y. State Geol., p. 34. (1890.)

plane of the valve, while in *S. textus* it slopes anteriorly and the angle with the plane of the valve is acute. The delthyrial plate in this species is distinctly keeled longitudinally while in *S. textus* it is nearly or quite flat upon its outer surface. The species resembles *S. typa* in the broad and large muscular impression of the pedicle valve and in the strong plications of the shell which are more nearly equal on the two valves than in many species of the genus.

Horizon.—Keokuk limestone.

Syringothyris solidirostris n. sp.

Plate LXX, Fig. 5

Description.—Shell large, wider than long, the greatest width along the hinge-line, the cardinal extremities angular. The type specimens are too fragmentary to give accurate measurements, but one incomplete pedicle valve has the following dimensions: maximum length from beak to front margin 50.5 mm., maximum width along hinge-line 57.5 mm., height of cardinal area 27 mm., width of delthyrium at hinge-line 18.5 mm.

Pedicle valve obliquely subpyramidal in form, most prominent at the umbo, the surface sloping to the cardinal extremities, the lateral and anterior margins with a gently convex curvature; mesial sinus non-plicate, originating at the beak, rather sharply defined, of medium depth and rounded in the bottom; the beak obtusely pointed, erect; cardinal area nearly flat, inclined posteriorly from the hinge-line at an angle greater than 90 degrees to the plane of the valve, and increasing with the age of the shell; delthyrium broad, its width two-thirds or more than two-thirds the height; each lateral slope of the valve marked by about 18 strong, simple, rounded plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities. Internally the rostral portion of the valve is nearly solidified back of the delthyrial plate, the continuous portion of the delthyrial plate is about three-fourths as long from the apex of the delthyrium as the total height of the delthyrium and is concave transversely, the free extension of the syrinx is relatively short and broad, and is attached nearly to its distal extremity to the floor of the valve; the dental lamellæ are short and rather thick and diverge much more widely than the lateral boundaries of the mesial sinus; the muscular scars are broad and deeply impressed, with a distinct, rounded, mesial elevation corresponding with the mesial sinus of the external surface of the valve.

In the condition of preservation of the type specimens the minute surface markings and punctate shell structure are obliterated. Rather strong concentric lines of growth are present which are distributed across the entire shell, but become somewhat more crowded anteriorly.

Remarks.—This species has been described from two imperfect pedicle valves, the brachial valve being unknown. It is characterized by the

great deposit of shelly matter at the beak and the essential solidification of the rostral portion of the valve; by the broad and deep muscular impression; by the strong plications of the shell; and by the nearly flat, posteriorly sloping cardinal area. The pedicle valve illustrated by Hall and Clarke,[1] as *S. subcuspidatus* is evidently an example of this species. This species differs from *S. subcuspidatus* in its flatter cardinal area, its longer and transversely concave delthyrial plate, and the solidification of the rostral portion of the pedicle valve.

Horizon.—Keokuk limestone.

Genus *PSEUDOSYRINX* n. gen.

Description.—Shell essentially like *Syringothyris* in its outer form and proportions. The pedicle valve with the lateral slopes usually rounding into the cardinal area; internally the dental lamellæ are elongate, sometimes reaching to or past the middle of the valve, the delthyrial plate well developed, reaching to varying distances towards the cardinal margin of the valve, its free margin describing a concave curve; no syrinx developed upon its inner surface. The surface of the cardinal area differentiated into three regions as in *Syringothyris,* and similarly marked. Punctate shell structure and fine textile surface markings as in *Syringothyris.*

Remarks.—The genus *Pseudosyrinx* has been established to include a group of spiriferoid shells with high cardinal area, punctate shell structure, and distinct delthyrial plate which differs from that in *Syringothyris* in the entire absence of a syrinx upon its inner surface. The various species of the genus have commonly been referred to one or another of the species of *Syringothyris,* but a careful investigation of a large number of specimens has led to the firm conviction that they should be placed in a distinct generic group differing from *Spirifer* in the main in the same manner as *Syringothyris,* and differing from *Syringothyris* in the absence of a syrinx. It was at first supposed that the absence of a syrinx in certain examples of spiriferoid shells with high cardinal area was accidental, but upon the continued occurrence of this feature in specimens preserved in such a way as to show certainly that no syrinx had ever been present, and the association of this condition with other characters of specific value, such as size, proportions of the shell, etc., the conclusion was forced that they should be separated under a new generic name. Besides the absence of the syrinx there are several other features which are more commonly present in *Pseudosyrinx* than in *Syringothyris;* the dental lamellæ are commonly continued further anteriorly along the floor of the pedicle valve than in *Syringothyris,* and the lateral margins of the cardinal area are more commonly marked by a rounding of the surface of the area into

[1] Pal. N. Y., vol. 8, pt. 2, pl. 26, fig. 11. (1894.)

the lateral slopes of the valve, than in *Syringothyris*. The little shell which has been described as *Syringothyris missouri* H. & C. has the external aspects of *Pseudosyrinx*, the long dental lamellæ and the rounded lateral margins of the cardinal area, and were it not for the fact that the syrinx has actually been observed in the type specimen, the species would be placed in this new genus. *P. missouriensis*, described in this report as a new species, is designated as the genotype of the new genus.

Pseudosyrinx differs from the genus recently described by Kindle as *Syringospira*,[1] in the continued divergence of the dental lamellæ throughout their entire length, and in the absence of plications upon the fold and sinus. In Kindle's genus the dental lamellæ converge anteriorly so as to become united a short distance in front of the apex of the valve and form with the delthyrial plate a subconical or tube-like chamber in the posterior portion of the pedicle valve, with its opening directed towards the opposite valve.

Pseudosyrinx sampsoni Weller

Plate LXVII, Figs. 11-13

1909. *Syringothyris sampsoni* Weller, Bull. Geol. Soc. Am., vol. 20, p. 311, pl. 14, fig. 4.

Description.—Shell large, wider than long, the greatest width at or near the hinge-line, the cardinal extremities apparently a little rounded or perhaps subangular. The dimensions of the holotype, a somewhat crushed specimen, are: length of pedicle valve from beak to front, approximately 50 mm., length of brachial valve approximately 45 mm., greatest width approximately 77 mm., length of hinge-line approximately 74 mm., height of cardinal area 56 mm., width of delthyrium at base 16 mm., width of sinus in front approximately 28 mm.

Pedicle valve subpyramidal in form, the surface sloping steeply from the umbonal region to the lateral and anterior margins; mesial sinus nonplicate, of moderate depth, rounded in the bottom, not sharply defined laterally, produced in front in a rounded lingual extension; beak small, pointed, slightly incurved; cardinal area of great height, nearly flat except just under the beak where it is a little concave; it slopes anteriorly from the hinge-line to the beak in the type specimen at an angle of apparently 30 degrees, although this may be too small; the lateral margins are not well preserved in the type but they apparently round rather abruptly into the lateral slopes of the valve, the triangular, vertically marked differentiated region lying on each side of the delthyrium has a width of base along the hinge-line about twice that of the base of the delthyrium and less than one-half the total length of the hinge-line; the delthyrium is narrowly triangular, its height being about three times its width at

[1] Bull. U. S. Geol. Survey, No. 391, p. 28. (1909.)

the base; each lateral slope bearing about 16 or 18 simple, depressed, nearly obsolete radiating plications which originate along the cardinal margin and become successively smaller towards the cardinal extremities. Internally the hinge-teeth are supported by conspicuous, slightly diverging, dental lamellæ which extend beyond the middle of the valve along its inner surface, their divergence being much less than that of the lateral margins of the mesial sinus; the delthyrial plate well developed, transversely concave, reaching about half way from the beak to the cardinal margin.

Brachial valve subsemicircular in outline, with a broad, rounded emargination in front, the greatest convexity probably near or at the front margin on the mesial line, the surface curving more abruptly to the cardinal margin, somewhat compressed towards the cardinal extremities; mesial fold non-plicate, rounded on top, slightly elevated at the beak, becoming broader and moderately elevated in front; beak small, incurved; plications of the lateral slopes simple, depressed, rounded, similar to those of the opposite valve, but very much stronger.

Surface of both valves marked by minute papillæ arranged in concentric rows, about 7 or 8 occupying the space of one millimeter; the papillæ of successive rows are alternate in position, and extending anteriorly from each is a minute groove which terminates at about the line of the next succeeding row of papillæ, taken in their aggregate the grooves give to the surface the appearance of being covered with minute shingles with a papilla at the lower extremity of each. Concentric lines of growth of moderate strength occur at more or less irregular intervals and continue across the cardinal area of the pedicle valve. Shell structure punctate.

Remarks.—This species most closely resembles *S. gigas,* and in many characters the two species do not differ. *S. sampsoni,* however, has a proportionally higher cardinal area and more narrowly triangular delthyrium, and the dental lamellæ are much less widely divergent. The type specimen is a badly crushed example so that the exact angle of the anterior slope of the cardinal area cannot be determined, but it is apparently somewhat smaller than that in *S. gigas.* The shell surface has been largely destroyed from the specimen, but where it is preserved, it exhibits the typical "twilled cloth" ornamentation of this genus and *Syringothyris.*

Horizon.—Fern Glen formation and Keokuk limestone.

Pseudosyrinx missouriensis n. sp.

Plate LXV, Figs. 5-9; Plate LXVI, Figs. 11-13

1894. *Syringothyris carteri* Keyes, Mo. Geol. Surv., vol. 5, p. 87, pl. 40, fig. 10.

Description.—Shell above medium size, broader than long, the greatest width near the hinge-line, the cardinal extremities narrowly rounded.

The dimensions of an incomplete but undistorted specimen are: length of pedicle valve from beak to front 22 mm., length of brachial valve 16 mm., width 38 mm., thickness approximately 22.5 mm., height of cardinal area 17 mm., width of sinus in front 11.5 mm., width of delthyrium at base 7.5 mm.

Pedicle valve subpyramidal in form, the surface sloping from the umbo to the lateral and anterior margins with a gently convex curve; the median sinus narrow and sharply defined at the beak, rounded in the bottom, of moderate depth, becoming broader and less sharply defined anteriorly; the beak small, pointed, slightly curved over the cardinal area; cardinal area nearly flat except near the apex, where it is gently arched just beneath the beak, the lateral margins not sharply defined but rounding into the lateral slopes of the valve, sloping anteriorly from the hinge-line at an angle of from 55 to 60 degrees to the plane of the valve, the triangular, vertically marked, differentiated region on each side of the delthyrium is rather narrow, the base of the triangle upon the hinge-line being considerably less than one-half the total length of the hinge-line; delthyrium narrowly triangular, the height nearly, or more than twice, the width at the base; each lateral slope marked by from 16 to 18 simple, depressed, radiating plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities. Internally, the dental lamellæ are well-developed, and extend anteriorly along the floor of the valve more than half way from the beak to the front margin, their divergence being the same as that of the sides of the median sinus; the muscular scars are narrow and not deeply impressed, with a low longitudinal ridge dividing them along the median line; the delthyrial plate is only a little depressed below the level of the cardinal area, and reaches less than half way from the apex of the delthyrium to the hinge-line, its outer surface is nearly flat or slightly convex transversely, and its free margin is a regularly concave curve.

Brachial valve much shallower than the pedicle, subsemicircular in outline, with a rounded emargination in front opposite the mesial fold, the surface curving more abruptly to the cardinal margin and becoming somewhat compressed towards the cardinal extremities; mesial fold of moderate height, rounded on top; each lateral slope bearing simple plications similar to those of the opposite valve but much more strongly defined.

The minute surface markings of both valves consist of very fine elongate papillæ abruptly raised at the anterior extremity and merging into the surface of the shell posteriorly, these papillæ are arranged in concentric rows and alternate with each other in position in succeeding rows. Shell substance minutely punctate. Concentric lines of growth of varying strength occur at intervals upon both valves and are sometimes crowded toward the front margin.

Remarks.—This species has been described in the main from specimens from the white cherts of Lower Burlington age, from Louisiana, Missouri. None of the specimens, from this locality, which have been studied are complete, but they preserve all of the essential characters and exhibit the fine surface markings in a most perfect manner. Several specimens from a similar horizon at Osceola, Missouri, are somewhat larger, the largest one having a width along the hinge-line of about 60 mm., but they agree with the Louisiana specimens in all essentials except in having a larger number of plications, there being 20 or more upon each lateral slope, a character doubtless due to the larger size of the individuals. The species differs from *S. gigas* in its smaller size, its greater angle between the cardinal area and the plane of the valve, and in the more rounded lateral margins of the area.

The shell illustrated by Keyes as *Syringothyris carteri* is certainly a member of this species, although it is proportionally somewhat wider along the hinge-line and consequently has a relatively lower cardinal area. It has the rounded lateral margins of the cardinal area of this species and closely resembles none of the species of *Syringothyris.*

Horizon.—Burlington limestone.

Pseudosyrinx keokuk n. sp.

Plate LXVI, Figs. 6-10; Plate LXVII, Figs. 1-9

Description.—Shell of about medium size, broader than long, the greatest width near the hinge-line, the cardinal extremities rounded. The dimensions of a nearly complete internal cast are: length of pedicle valve from beak to front margin 17 mm., length of brachial valve 15 mm., width 28 mm., length of hinge-line 22.5 mm., thickness 41.1 mm., height of cardinal area 9.8 mm., width of sinus in front 9.5 mm., width of delthyrium at hinge-line 5.4 mm.

Pedicle valve subpyramidal in form, the surface sloping in nearly straight lines from the beak to the lateral extremities and with a gently convex curvature to the antero-lateral and anterior margins; mesial sinus of moderate depth, rounded in the bottom, narrow and well defined at the beak, becoming broader and less sharply defined anteriorly, produced in front in a rounded lingual extension; beak small, pointed, a little curved; cardinal area nearly flat below, becoming gently concave towards the apex just under the beak, sloping anteriorly from the hinge-line at an angle of about 55 degrees to the plane of the valve, its lateral margins rounding regularly into the surface of the lateral slopes of the valve, the vertically marked, differentiated, triangular region lying on either side of the delthyrium has a width along the base of the triangle about equal to one-half the length of the hinge-line; delthyrium narrowly triangular, the width at the base about one-half the height; each lateral

slope with from 12 to 14 simple, depressed, radiating plications which originate along the cardinal margin and grow successively smaller towards the cardinal extremities. Internally the dental lamellæ are well developed and extend anteriorly from the beak along the floor of the valve for one-half or nearly one-half the length of the valve to the anterior margin on either side of the sinus, their divergence from the beak is a little greater than the divergence of the lateral margins of the median sinus; the muscular scars are usually faintly impressed and are either not divided longitudinally by a median ridge or by a very slight one; the delthyrial plate is rather short, reaching one-third or less than one-third of the distance from the apex of the delthyrium to the hinge-line, it is nearly flat or slightly convex transversely with a regularly concave free margin.

Brachial valve shallower than the pedicle, the greatest convexity on the median line at or near the front margin, the surface curving more abruptly to the cardinal margin, somewhat compressed towards the cardinal extremities; the mesial fold moderately elevated, rounded on top, well defined to the beak; the beak small, projecting a little beyond the cardinal margin, a little incurved; cardinal area narrow and inconspicuous, lying in nearly a right angle to the area of the opposite valve. Internally a distinct median septum extends a short distance forward from the beak and is then continued to about the middle of the valve as a slight median ridge; muscular scars obscure.

The minute surface markings of the shell are not well shown upon any of the specimens studied because of their condition of preservation, but suggestions of the "twilled cloth" form of ornamentation is recognizable upon some examples in patches; the shell structure is minutely punctate, the perforations extending also across the cardinal area of the pedicle valve to the border of the central, triangular, differentiated region where they stop abruptly; concentric lines of growth of varying strength are usually present at irregular intervals upon both valves.

Remarks.—This species is the smallest member of the genus recognized in our faunas, although it grows to a larger size than is indicated by the dimensions given, the largest individual which has been referred to the species having a width of 46 mm. This largest specimen is an internal cast of a pedicle valve in chert, and differs somewhat from the smaller examples in having longer dental lamellæ and in having the lingual extension of the sinus of greater length, but both these characters may be due to the greater age of the specimen. The holotype of the species is a nearly perfect internal cast from a white chert, its locality is not given but it might come from many exposures of such chert in the Keokuk formation of the Mississippi valley. The punctate structure of the shell is finely shown upon it as upon most other similar chert specimens, by the

siliceous papillæ which cover the surface of the specimens, these being the casts of the perforations in the original shell. The species is especially characterized by its small size, the broadly rounded lateral margins of the cardinal area, and the rounded cardinal extremities.

Horizon.—Keokuk limestone.

Pseudosyrinx gigas n. sp.

Plate LXVI, Figs. 1-5

Description.—Shell large, broader than long, the greatest width at or near the hinge-line, the cardinal extremities subangular or rounded. The dimensions of a nearly complete specimen are: length of pedicle valve from beak to front 50 mm., length of brachial valve 38 mm., width 82 mm., thickness 56 mm., height of cardinal area 43 mm., width of sinus in front 30 mm., width of delthyrium at base 18 mm.

Pedicle valve subpyramidal in form, the surface sloping with gentle curvature from the umbonal region to the lateral and anterior margins; the mesial sinus non-plicate, of moderate depth, rounded in the bottom and ill-defined laterally, produced anteriorly in a broad, rounded, lingual extension; beak small, pointed, slightly curved over the cardinal area; cardinal area very high, nearly flat from the hinge-line to a point near the apex where it is gently concave for a short distance below the beak, it slopes anteriorly from the hinge-line at an angle of about 40 degrees to the plane of the valve, and its lateral margins round rather abruptly into the lateral slopes of the valve, the triangular, vertically marked differentiated region lying on each side of the delthyrium is large, the base of this larger triangle occupying more than one-half the total length of the hinge-line; delthyrium narrowly triangular, the height more than twice the width; each lateral slope bearing about 16 simple, depressed, often ill-defined, radiating plications, which originate along the cardinal margin and become successively smaller towards the cardinal extremities. Internally the hinge-teeth are supported by well-defined dental lamellæ which are continued along the floor of the valve for nearly or quite one-half the length of the valve from the beak to the front margin, their divergence anteriorly being about equal to the divergence of the lateral boundaries of the mesial sinus; the delthyrial plate is well developed and extends from the apex of the delthyrium to a point from one-third to one-half the distance to the hinge-line; it is nearly flat or gently convex transversely and its free margin is a regularly concave curve.

Brachial valve subsemicircular in outline, with a deep, broadly rounded emargination in front opposite the mesial fold, the greatest convexity is on the median line at the front margin, the surface curves more abruptly to the cardinal margin and is somewhat compressed towards the cardinal

extremities, the umbonal region is rather strongly protuberant beyond the hinge-line; the mesial fold rounded on top, sharply defined and slightly elevated at the beak, becoming broader and of moderate height anteriorly; the beak small, broadly pointed and rather strongly incurved; cardinal area narrow, concave, lying at nearly a right angle to the area of the opposite valve; plications similar in number to those of the opposite valve but much more sharply defined.

The minute surface markings consist of exceedingly fine radiating striæ. Besides these, concentric lines of growth of greater or less strength are present which are often crowded at intervals, especially towards the front of the shell.

Remarks.—The specimen which has been selected as the holotype of this species is a nearly complete silicified specimen whose locality is unknown. Other less perfect examples from Warsaw, Ill., and Crawfordsville, Ind., have been studied. The species is characterized by its large size, the nearly flat cardinal area which becomes arched just beneath the beak, and by the small angle between the cardinal area and the plane of the valve. Because of the silicification of the shell the minute surface markings are not preserved upon the type specimen, but they are shown on the others and are best exhibited upon the Warsaw specimens. Upon one Crawfordsville example the fine radiating striæ appear on some parts of the shell to be interrupted at short and rather regular intervals, the intervals of interruption of adjacent striæ being similar along concentric lines, the striæ being alternate in position on either side of the lines of interruption. This arrangement gives to the surface markings an approach to the "twilled cloth" markings which are so characteristic of *Syringothyris* and of at least some of the species of this genus.

Besides the absence of a syrinx, this species differs from all the recognized species of *Syringothyris* in its general proportions, and can not be easily confused with any of them. There is a strong suspicion, however, that the species may be the same as that to which Troost[1] gave the name *Cyrtia gigas*. His description is entirely inadequate to allow the recognition of his species in the absence of the type or of authentic specimens, but the proportions of the cardinal area given by him are sufficiently near those of the specimen used for the definition here published, although Troost's specimen was somewhat larger. In order to avoid confusion in case Troost's species and this one should ever be proven to be the same, the same specific name has been used, a procedure which is allowable, since Troost's species has only been referred to the genera *Cyrtia* and *Syringothyris*.

Horizon.—Keokuk limestone.

[1] 6th Geol. Rep. Tenn., p. 12. (1841.)

Genus *SPIRIFERELLA* Tschernyshew

Description.—Shells large or small, both valves convex, the hinge-line shorter than the greatest width, the cardinal extremities rounded, mesial sinus in the pedicle valve and fold in the brachial valve well developed and without plications, or only slightly plicated, lateral slopes of the valve plicated. The pedicle valve with a moderately high cardinal area whose surface rounds into the lateral slopes of the valve; internally the dental lamellæ are very strongly developed and may extend anteriorly beyond the middle of the valve; they are joined posteriorly by a transverse delthyrial plate situated a little beneath the level of the general surface of the cardinal area; the muscular scars situated between the elongate dental lamellæ and resembling those of *Spirifer*. Brachial valve similar to that of *Spirifer* with a slight median septum internally. Shell substance punctate.

Remarks.—These shells have usually been included in the genus *Spirifer*, although *S. plenus* has sometimes been referred to *Syringothyris*. In none of the shells, however, is there any suggestion of a syrinx. They differ from *Spirifer* not only in the punctate shell structure, but in the exceedingly elongate dental lamellæ, and are really more closely allied to those shells that have been placed in the new genus *Pseudosyrinx* in this report than to any other. They differ from this last genus in their much more rotund form, in their much less elevated and more arched cardinal area of the pedicle valve, in their shorter hinge-line and in the more extravagant development of the dental lamellæ. They seem certainly to be congeneric with the shells described as *Spiriferella clausi* by Douville,[1] although there is some doubt as to any of these shells being certainly congeneric with *Spiriferella* as originally described by Tschernyshew.[2] For the present, however, it seems better to refer them to *Spiriferella* than to propose a new generic name for them.

Spiriferella plena (Hall)

Plate LXIII, Figs. 5-8; Plate LXIV, Figs. 1-4

1858. *Spirifer plenus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 603, pl. 13, figs. 4a-d.
1890. *Syringothyris ? plena* Schuchert, 9th Ann. Rep. N. Y. State Geol., p. 37.
1894. *Syringothyris plena* Keyes, Mo. Geol. Surv., vol. 5, p. 88, pl. 40, fig. 8.
1895. *Spirifer plenus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 37, figs. 32, 33.
1909. *Spirifer plenus* Weller, Bull. Geol. Soc. Am., vol. 20, p. 306.

[1] Bull. Geol. Soc. France, 4th ser., vol. ix, p. 153, pl. 5, figs. 3-5. (1909.)
[2] Mem. Com. Geol. de St. Petersbourg, vol. 2, No. 2, p. 513. (1902.)

Description.—Shell large, subglobose, wider than long, the hinge-line less than the greatest width of the shell, the cardinal extremities rounded. The dimensions of a nearly perfect individual are: length 56 mm., width 70 mm., thickness 48 mm., length of hinge-line 51 mm., height of cardinal area 11.5 mm.

Pedicle valve ventricose, the greatest convexity in the umbonal region, the surface curving abruptly in all directions from the umbonal region but most abruptly to the cardinal margin, the convexity of the valve extending out to the cardinal extremities; the beak not sharply pointed, a little incurved; cardinal area rather high, arched, the inferior portion making an angle of about 90 degrees to the plane of the valve, the curvature from the hinge-line to the beak describing nearly an arc of a circle, the lateral margins not sharply defined but rounding rather abruptly into the lateral slopes of the valve, the delthyrium large, forming nearly an equilateral triangle; lateral slopes of the valve each marked with from 16 to 20 simple, depressed, rounded plications, the smaller of which towards the cardinal extremities become nearly obsolete; mesial sinus narrow and shallow at the beak, growing rapidly broader towards the front, of moderate depth, rounded in the bottom, without plications, in full grown examples with the anterior extremity produced into a broad, lingual extension.

Brachial valve as convex or more convex than the pedicle, its greatest convexity usually at the anterior margin, the convexity extending to the cardinal extremities or rarely slightly compressed at the extremities; the beak incurved and the umbonal region projecting beyond the hinge-line; the mesial fold without plications, scarcely defined at the beak, becoming broad and high and rounded anteriorly; the lateral slopes with a steep, convex slope from the margins of the mesial fold to the margins of the valve, the slope becoming more abrupt to the cardinal margin, each bearing plications similar in form and number to those upon the opposite valve except that they are often a little more distinct.

The finer surface markings consist of exceedingly minute papillæ or granulations more or less rhombic in outline, with the longer axis longitudinal and slightly elevated anteriorly, arranged in more or less definite diagonal lines. More or less irregular concentric lines of growth are usually present which are sometimes crowded towards the anterior margin.

Internally the shell is characterized by the exceedingly elongate dental lamellæ in the pedicle valve, which extend with only moderate divergence nearly or quite one-half the length of the shell from the beak towards the anterior margin, these lamellæ are thick and bifoliate, splitting readily along their median plane; posteriorly a concave transverse plate joins the two dental lamellæ in a plane a little depressed below the general

surface of the cardinal area, this plate extends from the beak nearly to the hinge-line, its cardinal margin being concave.

Remarks.—In its non-plicated fold and sinus, in the transverse plate joining the posterior portions of the dental lamellæ, and in the minute surface ornamentation this species resembles members of the genus *Syringothyris,* to which genus it has sometimes been referred. However, the transverse plate in the delthyrium does not bear a syrinx upon its anterior surface with a projecting point at the median line towards the hinge-line, this feature of the shell being in essential accord with *Pseudosyrinx.* A similar surface ornamentation is not altogether lacking in the genus *Spirifer,* as several Devonian species possess it, and a similar transverse plate is also developed in some species of *Spirifer,* although in no other is it known to be so conspicuously developed as here. The characters which differentiate this species from *Pseudosyrinx* are the rotund form, the lower and more arched cardinal area, and especially the extravagant development of the dental lamellæ. The punctate structure of the shell is not commonly well preserved, and in none of the specimens examined by the writer has it certainly been seen. Schuchert,[1] however, says, "shell structure distinctly punctate," and he doubtless observed it in specimens more favorably preserved than any of those examined by the writer.

Horizon.—Burlington limestone.

Spiriferella latior n. sp.

Plate LXIII, Figs. 9-10

Description.—Shell large, broader than long, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete pedicle valve are: length about 45 mm., greatest width about 68 mm., length of hinge-line about 50 mm., height of cardinal area 16 mm.

Pedicle valve strongly convex, the greatest depth posterior to the middle in the umbonal region, the surface curving with a gentle convexity from the umbo to the anterior and antero-lateral margins, the slope from the umbo to the cardinal extremities being a little concave; the beak pointed and moderately incurved; the cardinal area large, concave, with the curvature increasing a little towards the beak, the lateral margins not sharply defined, the surface rounding into that of the lateral slopes of the valve; the delthyrium very large, broadly triangular; the mesial sinus originating at the beak, growing very broad anteriorly, rather shallow and regularly rounded in the bottom, well defined laterally, not marked by radiating plications; the lateral slopes each marked by from

1 9th Ann. Rep. N. Y. State Geol. for 1899, p. 37. (1890.)

20 to 25 depressed, rounded, simple plications which become successively fainter towards the cardinal extremities, the last four or five often being almost obsolete. Internally the dental lamellæ are remarkably developed as thick, bifoliate plates extending nearly to the front of the valve, between them, in the posterior portion of the valve, is a well developed delthyrial plate rather deeply depressed below the surface of the cardinal area with its free margin concave.

Brachial valve not observed.

Remarks.—This species is a close ally of *S. plenus* and might perhaps be considered as only a variety of that species. The exceedingly strong, bifoliate dental lamellæ are alike in both forms, but the one here described is proportionally much broader and shorter, with the pedicle valve much less strongly curved in an antero-posterior direction, and with a less strongly arched cardinal area.

Horizon.—Burlington limestone.

Spiriferella neglecta (Hall)

Plate LXIV, Figs. 5-9; Plate LXV, Figs. 1-4

1858. *Spirifer neglectus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 643, pl. 20, fig. 5,
1875. *Spirifer neglectus* Meek and Worthen, Geol. Surv. Ill., vol. 6, p. 523, pl. 30, figs. 1c, 2a.
1884. *Spirifera neglecta* Walcott, Pal. Eureka Dist., p. 217, pl. 18, fig. 10.

Description.—Shell above medium size, usually wider than long, but sometimes longer than wide, greatest width at about the mid-length of the shell, the hinge-line short, the cardinal extremities rounded. The dimensions of two individuals, the larger of which is somewhat distorted, are: length 51 mm. and 42 mm., greatest width 60 mm. and 39 mm., length of hinge-line 28 mm. and 21 mm., thickness 38 mm. and 28 mm., height of cardinal area 11 mm. and 9 mm.

Pedicle valve strongly convex or gibbous with its greatest convexity posterior to the middle, sometimes well up towards the umbonal region, the surface curving very abruptly from the umbonal region to the cardinal margin and less abruptly to the antero-lateral margins, the convexity of the valve extending out to the cardinal extremities; the beak pointed and incurved; cardinal area narrow and high, arched, the curvature increasing towards the beak, the inferior portion sloping posteriorly at an angle of less than 110 degrees to the plane of the valve, divided by a large delthyrium which occupies the central half of the total width of the true area on the hinge-line, the actual surface of the area being limited to two narrow bands which pass obliquely from the hinge-line to the beak, the lateral margins of the area not defined, its surface passing laterally without demarcation into a false cardinal area which rounds gradually into the lateral slopes of the valve; lateral slopes of the valve each bearing

from 6 to 8 broad, depressed, rounded, more or less obscure, simple plications, which become obsolete towards the cardinal extremities; mesial sinus originating at the beak, becoming broad and moderately deep towards the front, it is nearly flat in the bottom or more often is occupied by a broad, depressed convex region which can scarcely be called a plication, although in the narrower examples it assumes more the form of a plication, the lateral slopes of the sinus are convex and pass without demarcation into the surface of the lateral slopes of the valve.

Brachial valve a little less convex than the pedicle, its greatest convexity near the middle, the convexity extending out to the cardinal extremities; the beak slightly incurved and extending a little beyond the hinge-line; the mesial fold narrow at the beak, becoming broad and in large examples very high in front where it is rounded and free from plications; lateral slopes bearing plications similar in form and number to those of the opposite valve.

Shell structure punctate; the minute surface markings not preserved, but there are concentric lines of growth which are sometimes strongly developed and crowded towards the anterior margin.

In the internal casts of the shell preserved in residual cherts, the dental lamellæ of the pedicle valve are seen to be elongate, extending nearly one-third the total length of the valve from the beak towards the anterior margin, and diverging only to a moderate degree; the muscular impressions in the same specimens are scarcely defined.

Remarks.—This species is so distinctly marked that it cannot be confused with any other form. In the rounding of the lateral slopes of the pedicle valve into the false cardinal area it resembles *Spirifer subcardiiformis,* but it attains a larger size than that species and differs from it in the lack of any line of sharp demarcation between the false and the true cardinal area, as well as in the lack of plications in the fold and sinus, and in the punctate structure of the shell. In general form the species most closely resembles *S. plena,* but the cardinal area of the pedicle valve of that species is much larger and more defined, and the plications of the shell are narrower and much more numerous.

Horizon.—Keokuk limestone.

Spiriferella ? schucherti (Rowley)

Plate XXXV, Figs. 59-63

1900. *Spirifer schucherti* Rowley, Am. Geol., vol. 25, p. 261, pl. 5, figs. 15-17, 59.

Description.—Shell small, suborbicular in outline, a little wider than long, the greatest width at about the mid-length of the shell, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly perfect specimen, a metatype, are: length of pedicle valve 8.9 mm., length of brachial valve 7.5 mm., greatest width

9.4 mm., thickness 6.2 mm., length of hinge-line 5 mm., width of mesial sinus in front 3.7 mm.

Pedicle valve most convex posterior to the middle, the umbo prominent, the surface curving abruptly to the cardinal margin, and more gently to the lateral and anterior margins; the mesial sinus originating at the beak, sharply defined throughout its entire length by a pair of strong, rounded plications, rather shallow, of moderate width and rounded in the bottom, either without plications or with a single, simple median one originating back of the middle of the shell and continuing to the front margin with gradually increasing strength, but never becoming as strong as those of the lateral slopes of the valve; the beak prominent, pointed, rather strongly incurved; each lateral slope of the valve bearing from four to six rounded, simple plications which originate along the cardinal margin, the cardinal area small, concave, with the curvature increasing towards the beak, the lateral margins not sharply defined, the surface curving without interruption into the lateral slopes of the valve.

Brachial valve less convex than the pedicle, the greatest convexity near the middle, the surface curving more abruptly to the cardinal margin on each side of the beak, and gently to the antero-lateral margins, a little compressed towards the cardinal extremities; mesial fold well defined from the beak to the front margin, scarcely elevated above the general convexity in the posterior half of the valve, and only moderately elevated towards the front, a little flattened on top or with a slight longitudinal depression which is much fainter than the median plication in the sinus of the opposite valve; beak small, incurved, only slightly projecting beyond the cardinal margin; each lateral slope marked by from four to six simple, rounded plications entirely similar to those of the pedicle valve. Surface of both valves marked by very fine, closely crowded granules or papillæ, and the shell structure rather coarsely, but closely, punctate.

Remarks.—In its general outline this little shell at once suggests a minute individual of *Spirifer suborbicularis* or *S. chouteauensis*, but it differs notably from either of these species in the presence of the minute surface papillæ and the punctate shell structure. The punctate structure of the shell suggests the genus *Spiriferina*, but the general form is totally different from any of our other species of that genus, all of which have a more or less elongate hinge-line and well defined cardinal area with sharply defined lateral margins. The internal features of the shell have not been observed so that the presence or absence of a median septum in the pedicle valve is not known, if such a septum be present the species should doubtless be placed in the genus *Spiriferina*, in spite of its unusual external form. On the whole this little shell seems to agree most closely,

in all those characters which can be observed, with such punctate shells as *Spiriferella neglecta*. It has the same rotund form with short hinge-line and ill-defined cardinal area, and if it should be shown that it possesses greatly elongate dental lamellæ in the pedicle valve, without a median septum, the reference to *Spiriferella*, as used in this place, is doubtless correct.

Horizon.—Lower Burlington limestone.

Genus *ACANTHOSPIRA* n. gen.

Description.—Shell small, spiriferoid in form, and so far as known agreeing entirely with *Spirifer* in its internal characters and in its larger external features. The essential generic character consists in the presence of fine spines upon the surface, which in the genotype are arranged in regularly radiating series along the summits of the plications, and in similar rows on the fold and sinus.

Remarks.—This genus is established upon a single species which has been referred to *Spiriferina* by its original author, but the shell structure is apparently non-punctate and there is no evidence of a median septum in the pedicle valve. The presence of surface spines, such as the species possesses, is entirely foreign to the genus *Spirifer*, and consequently the shell has been made the type of a new genus.

Acanthospira aciculifera (Rowley)

Plate XXXV, Figs. 64-72

1893. *Spirifera aciculifera* Rowley, Am. Geol., vol. 12, p. 307, pl. 14, figs. 13-14.
1908. *Spiriferina aciculifera* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 84, pl. 18, figs. 13-15.

Description.—Shell small, broader than long, semicircular in outline, hinge-line a little shorter than the greatest width, the cardinal extremities a little rounded. The dimensions of the holotype are: length of pedicle valve 4.1 mm., length of brachial valve 3.9 mm., greatest width 5.6 mm., thickness 3 mm., length of hinge-line 4.8 mm., height of cardinal area 1.2 mm., width of mesial sinus in front 2 mm.

Pedicle valve subpyramidal in form, most prominent in the umbonal region, the surface sloping from the umbo to the lateral margins in nearly straight or slightly concave lines, the curvature to the antero-lateral and anterior margins gently convex; mesial sinus non-plicate, sharply defined, originating at the beak, rather shallow, flattened in the bottom; beak small, moderately incurved; cardinal area moderately high, nearly flat below, becoming concave towards the beak, the lower flattened portion lying in nearly a right angle to the plane of the valve, the lateral margins not sharply defined, the surface curving into the lateral slopes of the valve; an inner or secondary area is present, bounded laterally by a

pair of slightly elevated ridges which diverge from the beak to the hinge-line which they meet a little less than half-way from the margins of the delthyrium to the cardinal extremities, no differentiation in the ornamentation of the two portions of the area is recognizable in the type specimen; delthyrium open, rather large, its width at the base about equal to its height; each lateral slope marked by about seven simple, rounded, radiating plications which originate along the cardinal margin, the plications bounding the sinus are the largest, the others growing successively smaller to the last one, which is almost obsolete.

Brachial valve depressed convex, becoming compressed towards the cardinal extremities, most convex posterior to the middle, gently convex to the antero-lateral and anterior margins; mesial fold non-plicate, well defined, originating at the beak, rather low, flattened on top; the beak small, scarcely incurved, only slightly protuberant beyond the cardinal margin; each lateral slope marked by six plications entirely similar to those of the opposite valve and alternate with them.

Aside from the plications the surface of each valve is marked by regularly arranged, minute tubercles or papillæ which doubtless supported slender spines in the living shell, a single radial row of such tubercles is present upon the summit of each plication, in addition to which a single row occupies the median line of the sinus of the pedicle valve, and two rows the flattened portion of the fold of the brachial valve; very fine, more or less obscure, concentric lines of growth are also present upon each valve. Shell structure apparently not punctate.

Remarks.—In the apparent absence of any punctate shell structure, this species does not conform with the generic definition of *Spiriferina*, the genus to which it has been referred by its author. The internal characters of the pedicle valve are not clearly defined because of the complete retention of the shell substance, but the valve is sufficintly transparent to clearly show the presence of a pair of dental lamellæ diverging from the beak in line with the bounding plications of the mesial sinus, and extending for about one-third the length of the valve, while no median septum is apparent and is probably wanting in the species. The absence of the punctate shell structure, the dental lamellæ not united to form a spondylium, and the open delthyrium likewise exclude the species from *Cyrtina*. *Syringothyris* and its allies are also excluded by reason of the non-punctate shell and the absence of the peculiar surface markings of those genera, and no delthyrial plate or syrinx is known to be present. The species agrees most closely with the members of the genus *Spirifer*, but the presence of the regularly arranged, minute spines of a character foreign to that genus. The species is, therefore, considered as the type of the new genus *Acanthospira*.

Horizon.—Louisiana limestone.

Genus *MARTINIA* McCoy

Description.—Shells usually of medium size or smaller, subcircular, subovate or subelliptical in outline, the hinge-line short, the cardinal extremities rounded, the surface of the valves smooth or nearly so. The pedicle valve with a small cardinal area whose lateral margins are not sharply defined, the surface curving with little or no differentation into the lateral slopes of the valve, the delthyrium rather large; internally neither dental lamella nor median septum are present, the muscular scars are small, scarcely impressed and ill-defined. In the brachial valve the muscular scars are also inconspicuous, the crura and primary lamellæ of the brachidium are elongate, the bases of the spiral coils are situated well forward and their apices are directed towards the cardinal extremities.

Remarks.—In general external form and in the smoothness of the shell the members of this genus resemble some of the athyroid genera, but they always possess a distinct cardinal area, although it is small, with a rather large, open delthyrium. Waagen[1] has pointed out the presence of a minutely punctate structure in the epidermal layer of the shells of this genus, a structure which does not penetrate the inner layers of the shell, and considers it as one of the generic characters. This feature, however, has not been observed in any of the American shells which have come under observation, a fact which may be due to the destruction of the epidermal layer of the specimens observed.

Martinia contracta (Meek and Worthen)

Plate LXXV, Figs. 1-10

1861. *Spirifera glabra* var. *contracta* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 143.
1866. *Spirifer glaber* var. *contractus* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 298, pl. 23, figs. 5a-b.
1888. *Spirifer glaber* Herrick, Bull. Sci. Lab. Denison, Univ. vol. 4, pl. 11, fig. 15.
1891. *Spirifer* (*Martinia*) *contractus* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 583, pl. 13, figs. 17-19.
1894. *Spirifera contracta* Keyes, Mo. Geol. Surv., vol. 5, p. 83.
1895. *Spirifera* (*Martinia*) *contracta* Whitfield, Geol. Surv. Ohio, vol. 7, p. 471, pl. 9, figs. 17-19.
1909. *Martinia contracta* Bassler, Va. Geol. Surv., Bull. No. II A, pl. 29, fig. 11.
1911. *Martinia contracta* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 375, figs. 10a-c.

Description.—Shell subovate or ovate-subquadrangular in outline, longer than wide or with the length and width subequal, hinge-line short,

[1] Mem. Geol. Surv. India, ser. 13, pt. 1, p. 529. (1882.)

the cardinal extremities rounded, the greatest width near the mid-length of the shell. The dimensions of three nearly perfect specimens are: length of pedicle valve 28.3 mm., 21.5 mm. and 20.7 mm., length of brachial valve 24 mm., 18 mm. and 17.6 mm., maximum width 24.5 mm., 20.9 mm. and 20.9 mm., length of hinge-line 13 mm., 12.2 mm. and 9 mm., thickness 19.8 mm., 14 mm. and 14.3 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbo prominent and projecting posteriorly beyond the hinge-line, the surface curving abruptly to the cardinal margin, more gently to the lateral margins and most gently to the anterior margin; mesial sinus originating in the umbonal region, shallow or of moderate depth, rounded in the bottom or subangular along the median line, ill-defined laterally, a little produced anteriorly; beak rather prominent, strongly incurved; cardinal area small, strongly arched, the lateral margins not sharply defined, the surface curving almost without interruption into the lateral slopes of the valve except towards the cardinal extremities; delthyrium large, broadly triangular, occupying one-half or nearly one-half of the hinge-line at its base.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin and sloping with a gentle convexity from the median line to the lateral margins, convex along the median line from the beak to the front with an increasing curvature posteriorly, sometimes a little compressed towards the cardinal extremities; mesial fold ill-defined, scarcely differentiated in the posterior half of the valve, it is rounded on top and often has a slight mesial depression in the anterior half of the valve; beak small, incurved; cardinal area very narrow.

The surface markings of both valves, as shown upon exfoliated specimens, consist of fine, radiating costæ, about 2 or 3 of which occupy one millimeter near the margin, becoming finer towards the beak, these costæ increase usually by implantation and are of such strength that they must have been present upon the surface of non-exfoliated shells; crossing the radiating costæ are exceedingly fine concentric lines which are usually crowded at intervals, especially in the anterior half the shell, in stronger lines of growth.

Remarks.—In the original description of this species the presence of radiating markings is noted but they are described as being too fine to be observed with the unaided eye. Upon the specimens here described the radiating costæ are very distinct, agreeing more closely with the shells from Ohio which Whitfield has referred to the species than to the originals of Meek and Worthen. The specimens observed exhibit considerable variation in their proportional length and width, and in the angularity of the mesial sinus, the specimens with the more angular sinus having

the more conspicuous mesial depression along the median line of the fold of the brachial valve.

Horizon.—Chester group, Okaw limestone.

Martinia sulcata n. sp.

Plate LXXV, Figs. 11-14

Description.—Shell below medium size broadly subovate in outline, wider than long, the greatest width near the mid-length, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly complete specimen are: length of pedicle valve 21.4 mm., length of brachial valve 18.5 mm., greatest width 22.5 mm., length of hinge-line 9.5 mm., thickness 13.3 mm.

Pedicle valve strongly convex, the surface curving abruptly to the cardinal margin and somewhat more gently to the lateral and anterior margins, not compressed towards the cardinal extremities; the beak short and blunt rather strongly incurved; cardinal area small with lateral margins not sharply defined, its surface curving into that of the lateral slopes of the valve without interruption, the delthyrium about as wide as high; mesial sinus obsolete at the beak and in the umbonal region, originating posterior to the middle of the valve and rapidly deepening anteriorly, becoming very profound and subangular in the bottom towards the front, and moderately produced as an anterior extension of the valve, not sharply defined laterally; lateral slopes regularly convex.

Brachial valve usually a little less convex than the pedicle, the greatest depth near and anterior to the middle of the valve, the surface curving more abruptly to the cardinal margin, gently convex to the lateral margins, the median line from the beak to the front is convex posteriorly, becoming nearly straight in the central portion and in full grown shells continuing straight to the front or more often becoming a little concave; the umbonal region not prominent; the beak small and inconspicuous; the mesial fold obsolete in the posterior half of the valve but becoming rather strongly elevated in front where it is broadly rounded and ill-defined laterally.

The surface of both valves marked by very fine and inconspicuous radiating markings which can usually be seen only with difficulty, also by exceedingly fine and inconspicuous concentric lines of growth. Both these sets of markings are so faint that the surface appears to be perfectly smooth except upon close examination.

Remarks.—This species differs from *M. contracta* in its proportionally shorter and broader form, its much more profound mesial sinus towards the front of the pedicle valve, and in the less conspicuous radiating markings of the shell.

Horizon.—Chester group.

Genus *AMBOCŒLIA* Hall

Description.—Shells small, plano-convex or slightly concavo-convex, subcircular to subsemielliptical in outline, the hinge-line usually a little shorter than the greatest width of the shell, the cardinal extremities rounded. Surface of valves smooth or with fine concentric lines of growth, rarely minutely spinose, shell substance not punctate. Pedicle valve strongly convex with very prominent umbonal region, the beak strongly incurved, marked by a narrow, median, groove-like sinus which is usually strongest posteriorly; cardinal area well defined, concave, the delthyrium rather large and open, with incomplete deltidial plates. Internally the hinge-teeth are prominent, with recurved tips, not supported by dental lamellæ; the muscular area small, the interior surface about the muscular scars strongly pitted. Brachial valve convex at the beak, becoming flat or concave anteriorly, with a rather broad cardinal area lying in nearly a right angle to the area of the opposite valve; cardinal process bifurcate posteriorly, elongate, resting on the bottom of the valve except at the posterior extremity, the spires of the brachidium loosely coiled with few volutions, attached by long crura which are continuous with the primary lamellæ, the jugum in the same rudimentary condition as in *Spirifer*.

Remarks.—This genus of small shells may be easily recognized, in most cases, from the detached pedicle valves, the condition in which the species most commonly occur in our faunas, by reason of the smooth surface, the prominence of the umbonal region and the narrow, groove-like mesial sinus. The genus is represented by several species, all of which are restricted to the Kinderhook faunas.

AMBOCŒLIA MINUTA White

Plate LXXVII, Figs. 44-54

1862. *Ambocœlia* (*Spirifer?*) *minuta* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 26.
1894. *Ambocœlia minuta* Keyes, Mo. Geol. Surv., vol. 5, p. 90.
1908. *Ambocoelia minuta* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 85, pl. 18, figs. 21-24.

Description.—Shell minute, subplanoconvex, subsemielliptical in outline, the hinge-line a little shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of an average individual are: length of pedicle valve 2.3 mm., length of brachial valve 2 mm., greatest width 2.2 mm., length of hinge-line 1.5 mm., thickness 1.9 mm., the largest examples observed do not exceed 3 mm. in maximum length.

Pedicle valve gibbous, the greatest depth opposite the hinge-line, the umbo prominent, the surface curving abruptly from the umbonal region

to the cardinal margin and a little more gently to the lateral and anterior margins; beak obtuse, scarcely incurved; cardinal area high, the inferior portion nearly flat, and lying at an angle of about 90 degrees to the plane of the valve, becoming a little arched towards the beak, the lateral margins not defined, the surface curving with almost no demarcation into the lateral slopes of the valve; the delthyrium large, open, a little higher than wide; the lateral slopes convex, smooth; mesial sinus narrow and shallow, rounded in the bottom, not sharply defined laterally, originating in the umbonal region anterior to the beak, sometimes nearly or quite obsolete.

Brachial valve nearly flat, the beak obtusely pointed and produced horizontally a little beyond the hinge-line, the surface most prominent in the umbonal region, a little compressed towards the cardinal extremities, the mesial portion of the valve depressed in a broad, shallow, ill-defined sinus which originates at about the posterior third of the valve and widens rapidly until it occupies nearly one-half the total width of the valve towards the front.

Both valves are entirely non-plicate, but the surface is completely covered with minute, imbricating spines in perfectly preserved specimens.

Remarks.—This species occurs in great numbers in the shaly partings near the base of the Louisiana limestone, many complete examples being recovered from the washings. The species is characterized by its minute size, by the gibbosity of the pedicle valve and its obtuse beak, and by the character of the minute surface markings.

Horizon.—Louisiana limestone of the Kinderhook.

Ambocœlia parva Weller

Plate LXXVII, Figs. 32-35

1899. *Ambocoelia parva* Weller, Trans. St. Louis Acad. Sci., vol. 9, p. 20, pl. 4, figs. 1-4.

Description.—Shell small, subovate in outline, the length and width equal or the width greater than the length, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 4.7 mm. and 3.4 mm., width 4.8 mm. and 3.6 mm., convexity 2.3 mm. and 1.3 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region projecting notably beyond the hinge-line posteriorly; the surface somewhat flattened in the median region from the beak to the anterior margin, laterally the surface curves abruptly towards the cardinal extremities and a little more gently to the lateral margins; beak obtusely rounded, moderately incurved; cardinal area of moderate height, arched, apparently not sharply defined at its lateral margins, the surface curving into the lateral slopes of the valve without

differentiation; lateral slopes convex, smooth; mesial sinus originating at the beak, narrow, angular in the bottom, not sharply defined laterally, dividing the median flattened region of the valve along its middle line.

Brachial valve not known.

Remarks.—The type specimens of this species are from a fine-grained yellow sandstone from which all the shell substance has been removed. The specimens, however, are not internal casts of the shell but apparently retain the external configuration of the shell. The surface of the shell, as preserved, is entirely smooth without lines of growth or other surface ornamentation. The species differs from *A. minuta* in its larger size, its less gibbous pedicle valve with the umbonal region projecting farther posteriorly, and in the absence of the covering of fine surface spines.

Horizon.—Northview sandstone of the Kinderhook.

AMBOCŒLIA UNIONENSIS n. sp.

Plate LXXVII, Figs. 36-43

Description.—Shell small, wider than long, subelliptical in outline, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 8.3 mm. and 5.4 mm., width 10.3 mm. and 5.6 mm., convexity 3.6 mm. and 2.5 mm., length of hinge-line 7.5 mm. and 3.6 mm.

Pedicle valve strongly convex, subhemispherical in form, the greatest convexity near or posterior to the middle, the umbonal region broad and projecting posteriorly beyond the hinge-line to only a moderate degree; the surface curving abruptly from the umbonal region towards the cardinal margin, and more gently to the lateral and anterior margins; beak short, obtuse, only a little incurved; cardinal area of moderate height, arched, the lateral margins slightly defined, sloping in nearly straight or slightly concave lines from the beak to the cardinal extremities, the delthyrium large, its base occupying one-third or more of the total hinge-line; lateral slopes of the valve smooth, convex towards the middle of the valve, becoming somewhat compressed towards the cardinal extremities in large individuals; mesial sinus originating at the beak, narrow, angular in the bottom, not sharply defined laterally.

Brachial valve much less convex than the pedicle, the greatest depth about half way between the middle of the valve and the posterior margin, the surface compressed towards the cardinal extremities; the beak obtusely pointed and extending a little beyond the hinge-line posteriorly; the median portion of the valve depressed in a broad, shallow, ill-defined sinus which originates near the beak and becomes rapidly broader towards the front.

The surface of both valves marked by usually well defined but not always strong concentric lines of growth, aside from which the surface is apparently unornamented.

Remarks.—This species differs from *A. minuta* in its larger size, its proportionally much less convex pedicle valve, and in the absence of the minutely spinose surface markings. It is more nearly like *A. parva*, but differs from that species in its larger size, in the more obtuse beak of the pedicle valve, and in the more conspicuous development of the concentric lines of growth.

Horizon.—Kinderhook (Rockford limestone).

Ambocelia levicula Rowley

Plate LXXVII, Figs. 26-31

1900. *Ambocoelia levicula* Rowley, Am. Geol., vol. 25, p. 262, pl. 5, figs. 12-14.

1911. *Ambocœlia levicula ?* Girty, Bull. U. S. Geol. Survey, No. 439, p. 73, pl. 8, figs. 7-9.

Description.—Shell small, broader than long, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of a very perfect example, a metatype, are: length of pedicle valve 5 mm., length of brachial valve 4.1 mm., greatest width 5.6 mm., thickness 3.4 mm., length of hinge-line 3.5 mm.

Pedicle valve strongly convex, most prominent in the umbonal region, the surface curving abruptly to the cardinal margin on either side of the beak, and more gently to the lateral and anterior margins; the mesial sinus faint, very narrow and shallow, originating at or near the beak, becoming less well defined anteriorly; the beak prominent and strongly incurved; cardinal area small, concave with the curvature increasing towards the beak, differentiated from the lateral slopes of the valve along its lateral margins by a slight angulation of the surface extending from either side of the beak to the cardinal extremities, the delthyrium rather large, its base occupying nearly one-third of the entire hinge-line.

Brachial valve depressed convex, the greatest convexity posterior to the middle, the surface somewhat compressed towards the cardinal extremities, gently convex to the antero-lateral and anterior margins; a mesial flattening of the valve originates in the umbonal region which passes into a rapidly widening, but very shallow, ill-defined mesial sinus anteriorly; the beak very small, scarcely or not at all incurved, projecting very slightly beyond the cardinal margin.

Surface of both valves essentially smooth in the specimens examined, with neither concentric nor radiating markings.

Remarks.—This species is most closely allied to *A. parva* from the Northview sandstone, but differs from that species in being proportionally wider, and in having a much fainter mesial sinus in the pedicle valve.

Horizon.—Burlington white chert.

Genus *RETICULARIA* McCoy

Description.—Shells small, of medium size or larger, subovate, subcircular or subelliptical in outline, the hinge-line shorter than the greatest width of the shell, the cardinal extremities rounded, the fold and sinus moderately developed or essentially obsolete. The pedicle valve with a rather small, arched cardinal area whose margins are usually ill-defined, the surface usually rounding with but little or no interruption into the lateral slopes of the valve; the delthyrium rather large and open. Internally the dental lamellæ are strong and elongate sometimes extending anteriorly along the floor of the valve for more than one-third its length, they may be nearly parallel or moderately divergent, between them, in the median line of the valve, is a strong median septum which commonly reaches further anteriorly than the dental lamellæ, the muscular area subrhomboidal in outline, usually not deeply impressed. The brachial valve less convex than the pedicle, with narrow cardinal area; internally the brachidium is similar to that of *Spirifer*, so far as known, the muscular area is elongate ovate in outline and faintly impressed, often scarcely recognizable, it is divided longitudinally by a median septum of greater or less strength, which is sometimes almost obsolete. The surface of both valves is covered by regular, concentric rows of fine spines, which are in the form of double tubes, the position of these double tubed spines is clearly shown upon the exfoliated shell layers and sometimes upon the casts of the interior of the shells, but the tubes do not penetrate the full thickness of the shell.

Remarks.—These shells have often been considered as being not generically distinct from *Spirifer*, but their surface markings are so very different from members of that genus that most writers of recent years have given the group full generic rank. The genus has sometimes been made to include a group of species from the Pennsylvanian and Permian faunas which possess similar surface markings of concentric rows of double tubed spines, but which differ from these Mississippian shells in the entire absence of septal lamellæ in either valve. It has been pointed out by Girty,[1] however, that the genotype of *Reticularia* was one of these septate shells, and the non-septate form has been referred by the same author to the genus *Squamularia* Gemmellaro. All the Mississippian species which have been observed possess the internal septal plates and must be referred to *Reticularia*.

[1] Carb. Form. and Faunas of Colorado, p. 387. (1903.)

Reticularia cooperensis (Swallow)

Plate LXXV, Figs. 21-33

1860. *Spirifer Cooperensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 643.
1862. *Spirifer hirtus* White and Whitfield, Proc. Boston Soc. Nat. Hist., vol. 8, p. 293.
1865. *Spirifera hirta?* Winchell, Proc. Acad. Nat. Sci. Phil., p. 119.
1869. *Spirifera hirta?* Winchell, Safford's Geol. Tenn., p. 442.
1870. *Spirifera hirta?* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 251.
1888. *Spirifer ? hirtus?* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 47, pl. 3, fig. 2.
1888. *Spirifer hirtus* Herrick, Bull. Sci. Lab. Denison Univ., vol. 4, pl. 10, fig. 20.
1894. *Spirifera cooperensis* Keyes, Mo. Geol. Surv., vol. 5, p. 78.
1895. *Spirifer hirtus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 38, fig. 14.
1895. *Spirifer* (e.f.) *hirtus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 84, figs. 36-37.
1899. *Reticularia cooperensis* Girty, Mon. U. S. Geol. Surv., vol. 32, p. 555, pl. 70, figs. 9a-c.
1900. *Reticularia cooperensis* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 80, pl. 2, fig. 11.
1901. *Reticularia cooperensis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 166, pl. 14, figs. 14-15.

Description.—Shell below medium size, broader than long, subellipitical in outline, the hinge-line much shorter than the greatest width, the cardinal extremities rounded, the lateral margins regularly rounded, the anterior margin gently rounded, sometimes nearly straight in the middle. The dimensions of a nearly perfect individual are: length of pedicle valve 17.3 mm., length of brachial valve 15 mm., maximum width 21.3 mm., length of hinge-line 12 mm., thickness 11.9 mm., height of cardinal area 21.1 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, much less abruptly to the lateral margins and more gently to the anterior margin; mesial sinus originating in the umbonal region, shallow, ill-defined, and rounded in the bottom, sometimes almost or quite obsolete; beak rather small, incurved; cardinal area of moderate height, concave with the curvature increasing towards the beak, the lateral margins defined by only a slight angulation of the surface from the lateral slopes of the valve; delthyrium open, broadly triangular, its width at the base being about one-half the total width of the cardinal area. Internally the hinge-teeth are strengthened by a pair of dental lamellæ which diverge from the beak in an angle of 20 to 25 degrees or sometimes considerably more and extend along the floor of the valve for about one-fourth its length; between the dental lamellæ a median septum extends

from the beak to about the middle of the valve, being about twice the length of the dental lamellæ; the muscular scars are obscure, being scarcely differentiated from the general inner surface of the valve; the shell itself is thin so that the concentric markings of the external surface are clearly shown upon the internal casts, which are also marked by fine, irregular, more or less inconspicuous radiating costæ.

Brachial valve less strongly convex than the pedicle, the greatest convexity posterior to the middle, the surface curving somewhat abruptly to the cardinal margin and rather gently to the lateral and anterior margins, moderately compressed towards the cardinal extremities; mesial fold obscure or obsolete, when present it is very low, rounded on top, and is ill-defined laterally; the beak is small, short, and a little incurved, the umbonal region projects a little beyond the cardinal margin; cardinal area narrow, nearly horizontal in position. Internally the cardinal process is scarcely differentiated; a median septum which rapidly becomes only a slight, raised rib along the floor of the valve, extends to a point between one-third and one-half the length of the valve from the beak; at the beak the cardinal process is flanked by a pair of rather strong but short crural plates which join the median septum; the muscular scars are scarcely or not at all differentiated from the general inner surface of the valve.

The surface of both valves is marked by moderately broad, concentric bands which are beset with closely arranged fimbriæ or fine spines, those of successive bands being imbricating in arrangement.

Remarks.—This species is a close ally of *R. pseudolineata,* but is always smaller and is commonly proportionally thicker and narrower. Internally the radiating costæ of the shell which are so characteristic in *R. pseudolineata* are much less strongly developed than in that species. In the condition of preservation in which it is commonly found, the surface of the shell is exfoliated and the exact nature of the concentric rows of spines is not clearly shown, but they are probably of the double-tubed type similar to those of *R. pseudolineata.*

The species differs from *R. tenuispinata* of the Ohio Waverly, in its greater proportional length and in the less conspicuous development of the internal radiating costæ, that species being more nearly like a diminutive *R. pseudolineata.*

Horizon.—Kinderhook.

Reticularia pseudolineata (Hall)

Plate LXXIV, Figs. 1-11; Plate LXXV, Fig. 20

1858. *Spirifer pseudolineatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 645, pl. 20, fig. 4.

1883. *Spirifera pseudolineata* Hall, Rep. N. Y. State Geol. for 1882, pl. (36) 61, figs. 28-30.

1891. *Spirifer pseudolineatus?* Herrick, Bull. Geol. Soc. Am., vol. 2, p. 45, pl. 1, fig. 18.
1894. *Spirifer pseudolineatus* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 25, fig. 15.
1894. *Spirifera pseudolineata* Keyes, Mo. Geol. Surv., vol. 5, p. 82.
1895. *Spirifer pseudolineatus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 36, figs. 28-30.

Description.—Shell above medium size, transversely subelliptical in outline with the lateral margins symmetrically rounded, length of the hinge-line about two-thirds the width of the shell, the cardinal extremities rounded. The dimensions of two nearly complete specimens are: length of pedicle valve 32.6 mm. and 29.3 mm., length of brachial valve 28.2 mm. and 24.7 mm., maximum width 38.5 mm. and 33.3 mm., length of hinge-line 26 mm. and 22 mm., thickness 23 mm. and 21.4 mm., height of cardinal area 6.5 mm. and 6 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, much less abruptly to the lateral margins and still more gently to the anterior margin; mesial sinus ill-defined, usually shallow and of moderate width, obsolete at the beak but originating in the umbonal region; beak rather small, pointed, incurved, projecting beyond that of the opposite valve; cardinal area of moderate height, concave, becoming more curved towards the beak, its lateral margins ill-defined, the surface curving into that of the lateral slopes of the valve with only slight differentiation, the surface vertically striate; delthyrium broadly triangular, open. Internally the hinge-teeth are supported by a pair of strong dental lamellæ which extend about one-fourth the length of the valve from the beak towards the anterior margin, diverging at an angle between 30 and 40 degrees; between the dental lamellæ is a long median septum which reaches to the middle of the valve or farther, being from two to three times the length of the dental lamellæ; the muscular scars are longitudinally subrhomboidal or angularly subovate in outline, with their surface usually nearly flush with the floor of the valve, their anterior limit is marked by a slightly raised ridge passing from the posterior termination of the dental lamellæ to the posterior extremity of the median septum, the anterior portion of the ridge being gently convex and the posterior half usually nearly straight; the entire inner surface of the valve, even that of the cardinal area and the greater part of the muscular scar, is covered by fine radiating costæ, from 2 to 5 of which occupy the space of 1 mm.

Brachial valve less convex than the pedicle, the greatest convexity near or posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the lateral and anterior margins, sometimes very slightly compressed towards the car-

dinal extremities; mesial fold usually obscure or obsolete except near the front margin where it is low and ill-defined, but sometimes more prominent and originating in the umbonal region; the beak short, incurved, the umbonal region projecting beyond the cardinal margin; cardinal area narrow, lying nearly in the plane of the valve. Internally the cardinal process is scarcely more than a small, concave, differentiated region of the inner surface of the valve just under the beak, marked by fine vertical ribs and furrows, anteriorly from the cardinal process a median septum of greater or less strength extends one-third or more of the length of the valve, and on either side the cardinal process is flanked by strong crural plates which are joined to the median septum; the muscular scars are poorly defined; the entire internal surface covered by fine radiating costæ similar to those of the opposite valve.

Surface of both valves marked by concentric bands of crowded, regularly arranged, double-tubed, oblique spines, the successive rows of which are imbricating in arrangement, the bases of the spines are continued posteriorly to the next concentric band as a slightly raised ridge, giving to the surface of the shell when slightly worn the appearance of having both concentric and radiating markings, with the radiating markings much finer than the concentric ones. The radiating costæ of the interior of the valve are not infrequently clearly visible upon partially exfoliated specimens.

Remarks.—Hall's original specimen of this species is recorded from the Keokuk limestone of Keokuk, Iowa. It differs from most of the examples from that locality in having a more strongly developed mesial fold and sinus, although occasional specimens are found which have this character even more strongly marked than in the type. The type specimen is not in a condition to show the internal radiating costæ of the species but this character is well developed in all specimens preserved in such a condition as to exhibit it, and in internal casts from the chert it is especially well shown. The species differs from *R. setigera* from the higher Mississippian beds, in the strong development of these internal radiating costæ, in the lesser development of the fold and sinus and in the finer rows of concentric spines. The strong development of the internal markings seems to be, perhaps, the most characteristic feature of the species.

Horizon.—Keokuk limestone.

Reticularia setigera (Hall)

Plate LXXIV, Figs. 12-22

1858. *Spirifer setigerus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 705, pl. 27, figs. 4a-b.

1877. *Spirifera setigera* Hall and Whitfield, U. S. Geol. Expl. 40th Par., vol. 4, p. 270, pl. 5, figs. 17-18.

1883. *Spirifera setigera* Hall, Rep. N. Y. State Geol. for 1882, pl. (36) 61, figs. 26-27.
1894. *Spirifer setigerus* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 36. figs. 26-27.
1894. *Spirifera setigera* Keyes, Mo. Geol. Surv., vol. 5, p. 83.
1906. *Reticularia setigerus* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1318, pl. 21, figs. 1-1a.
1906. *Reticularia pseudolineata* ? Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1317, pl. 20, figs. 6-6a; pl. 21, fig. 5.
1911. *Reticularia setigera* Girty, Bull. U. S. Geol. Survey, No. 439, p. 69, pl. 8, fig. 6.

Description.—Shell of medium size or larger, usually a little wider than long, sometimes with the length and breadth nearly equal, subelliptical or subcircular in outline, the hinge-line about one-half the width of the shell, the cardinal extremities rounded. The dimensions of a nearly perfect specimen are: length of pedicle valve 24 mm., length of brachial valve 21.3 mm., maximum width 27.5 mm., length of hinge-line 14 mm., thickness 17.5 mm., height of cardinal area 4.4 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbo to the cardinal margin, and more gently to the lateral and anterior margins; mesial sinus originating at the beak or in the umbonal region, shallow or of moderate depth, ill-defined laterally, rounded in the bottom; beak pointed, rather strongly incurved; cardinal area of moderate height, concave with increasing curvature towards the beak, not sharply defined at the lateral margins, the surface curving into that of the lateral slopes with only a slight line of differentiation, the surface of the area vertically striate, the lateral margins of the delthyrium bordered by thin, elevated, and somewhat deflected ridges; delthyrium broadly triangular, rather large, open. Internally the hinge-teeth are supported by rather strong dental lamellæ which usually diverge anteriorly from the beak at an angle of from 25 to 40 degrees, and extend from one-fourth to one-half of the total length of the valve; between the dental lamellæ is a well-developed median septum which is considerably longer than the lamellæ, sometimes reaching to the middle of the valve; the muscular scars are rather narrow, limited laterally by the dental lamellæ, not deeply impressed, their anterior margins marked by rather indefinite raised ridges which extend obliquely from the anterior extremities of the dental lamellæ to the extremity of the median septum; in the umbonal region, including the surface of the muscular scars, the inner surface of the valve is marked by radiating costæ which rarely reach beyond the middle of the valve.

Brachial valve less convex than the pedicle, the surface curving abruptly to the cardinal margin from the umbonal region, and more gently to the lateral and anterior margins, sometimes a little compressed towards the cardinal extremities; mesial fold originating at the beak

or in the umbonal region, ill-defined laterally, rounded on top, low or of moderate height; beak short and incurved, the umbonal region extending a little beyond the hinge-line; cardinal area small, lying in nearly the plane of the valve, vertically marked by striæ similar to those of the opposite valve. Internally the anterior face of the cardinal process is flattened or concave, and is marked by fine vertical grooves, being scarcely differentiated, except by these markings, from the surface of the strong crural plates which flank it on either side, anteriorly from the cardinal process a well-defined median septum extends for one-third, or nearly one-third, the length of the valve; the muscular scars not well defined; the deeper portion of the valve marked by radiating costæ similar to those in the opposite valve.

The surface markings of both valves consist of regular, concentric, imbricating rows of fine, double-tubed spines, the bases of these spines are continued posteriorly upon the surface of the shell as slight ridges which reach to the next adjacent concentric band. When partially worn, the markings frequently appear to consist of rather regular, concentric bands, crossed by much finer radiating costæ.

Remarks.—This species is a close ally of *R. pseudolineata,* but may be distinguished from it by its proportionally narrower form, its more strongly developed mesial fold and sinus, the less strongly developed internal radiating costæ, and the somewhat more remote concentric rows of rather coarser spines upon the external surface. In the typical expression of each species they are not easily confused, but an occasional example of *R. pseudolineata* with more strongly marked fold and sinus resembles this species, but such specimens are commonly proportionally wider.

The species is typically developed in the Chester faunas, but it occurs not uncommonly in beds as low as the Salem limestone, but these earlier representatives are often of larger size. The dimensions which have been given are those of a Chester specimen of about average size, but in the Salem limestone the species sometimes attains a length of 30 or 40 mm., being as large as *R. pseudolineata.*

Horizon.—Salem limestone, Chester group.

Reticularia salemensis n. sp.

Plate LXXV, Figs. 15-19

Description.—Shell above medium size, subelliptical in outline, broader than long, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of the type specimen are: length of pedicle

valve 33 mm., length of brachial valve 27.5 mm., maximum width 37 mm., length of hinge-line 22 mm., thickness 22.5 mm., height of cardinal area 4.5 mm.

Pedicle valve rather strongly convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, less abruptly to the lateral and still more gently to the anterior margin; mesial sinus shallow, rather broad, ill-defined, originating in the umbonal region; beak apparently of moderate size, incurved; cardinal area of moderate height, concave, the lateral margins not defined, the surface curving into the lateral slopes of the valve with no line of differentiation; the delthyrium open, broadly triangular. Internally the hinge-teeth are supported by a pair of rather strong dental lamellæ of unknown anterior extension, between which is a median septum whose anterior extension is also unknown; character of the muscular scars and the internal configuration of the valve unknown.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the umbo projecting somewhat beyond the cardinal line, the surface curving abruptly to the cardinal margin and much more gently to the lateral and anterior margins, somewhat compressed towards the cardinal extremities; mesial fold almost obsolete, only slightly distinguishable towards the front of the valve, where it is only slightly differentiated from the general convexity; beak short and incurved; cardinal area inconspicuous. The internal characters of the valve not observed.

Surface of both valves marked by regular concentric bands from 2 to 3 mm. in width along the median line of the shell, the surface of each successive band being slightly but abruptly depressed below the one immediately preceding it; the concentric bands are marked by low, elongate nodes about 1 mm. apart, which are arranged in more or less regular radiating lines from the beak to the lateral and front margins and which are more prominent towards the anterior margin of the concentric bands. Upon some portions of the shell the anterior extremities of the nodes are distinctly bilobed, showing that they were produced in double-tubed spines.

Remarks.—The type specimen of this species is a nearly complete example with the beak of the pedicle valve slightly restored. The shell surface is exfoliated so that the surface spines have nowhere been preserved, but the character of the nodes which represent the spine bases are such as to indicate that the characteristic double-tubed spines of the genus were present. The species differs from *R. setigera*, which occurs in the same fauna, in the slightly developed or nearly obsolete fold and sinus and in the much coarser surface spines. From *R. pseudolincata* of the lower beds it differs in the much coarser spines, somewhat greater proportional length, and apparently in the absence of the distinct internal radiating costæ. The internal characters of the shell are not clearly exhibited in

the type specimen, although where the beak of the pedicle valve is fractured the character of the dental lamellæ and median septum can be observed.

Horizon.—Salem limestone.

Family RHYNCHOSPIRIDÆ

Genus *PTYCHOSPIRA* Hall

Description.—Shells small, biconvex, subcircular in outline, the hinge-line short, the valves bearing a few, strong, subangular, simple plications. Pedicle valve with an erect or moderately incurved beak perforated by a circular foramen, the cardinal area small and sharply defined along its lateral margins, the delthyrium more or less completely closed by the pseudodeltidium, not including the foramen. The brachial valve with convexity about equal to that of the pedicle, internally the hinge-plate is supported by a well-defined median septum, and the spires are constituted of but four or five volutions. The epidermal layer of the shell is finely pitted but the punctations do not continue into the deeper layers of the shell.

Remarks.—This genus is easily recognized by reason of its subequally convex valves, its subcircular outline, and its few but strong plications. It has only been observed in faunas of Kinderhook or lower Burlington age.

PTYCHOSPIRA SEXPLICATA (White and Whitfield)

Plate LXXVI, Figs. 35-46

1862. *Retzia sexplicata* White and Whitfield. Proc. Boston Soc. Nat. Hist., vol. 8, p. 294.
1892. *Retzia plicata* Miller, Adv. Sheets 18th Rep. Geol. Surv. Ind., p. 62, pl. 9, figs. 29-31.
1894. *Retzia plicata* Miller, 18th Rep. Geol. Surv. Ind., p. 316, pl. 9, figs. 29-31.
1894. *Ptychospira sexplicata* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 36, figs. 22-23.
1895. *Ptychospira* (cf.) *sexplicata* Hall & Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 50, figs. 13-14.
1895. *Ptychospira sexplicata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 83, fig. 28.
1900. *Retzia ? raricosta* Rowley, Am. Geol., vol. 25, p. 266, pl. 5, figs. 34-37.
1904. *Ptychospira sexplicata* Greger, Am. Geol., vol. 33, p. 15.
1909. *Ptychospira sexplicata* Weller, Bull. Geol. Soc. Am., vol. 20, pl. 315, pl. 14, fig. 11.

Description.—Shell small, subcircular in outline, usually a little wider than long but sometimes longer than wide, sublenticular to subglobular in form, the valves subequally convex, the greatest width near the mid-

length, the hinge-line much shorter than the greatest width of the shell, the cardinal extremities rounded. The dimensions of two nearly perfect specimens are: length of pedicle valve 9.5 mm. and 8.8 mm., length of brachial valve 8.4 mm. and 7.6 mm., width 10.5 mm. and 9.7 mm., thickness 5.3 mm. and 6.3 mm., length of hinge-line 4.1 mm. and 4 mm.

Pedicle valve most convex posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins, sometimes slightly compressed towards the cardinal extremities; no mesial sinus present other than the median furrow between the plications of the valve; the beak rather small, blunt at the extremity, moderately incurved, pierced by a small subcircular foramen; cardinal area small, broadly triangular in outline, gently arched, lying in nearly the plane of the valve, its lateral margins sharply defined; the delthyrium broadly triangular, occupying nearly one-half the width of the cardinal area along the hinge-line, its apex connecting with the foramen which encroaches entirely upon the beak of the valve, closed by a pair of deltidial plates; surface of the valve marked by from six to twelve strong, rounded, simple plications which are separated by deep, rounded grooves about equal in width or a little wider than the plications themselves, the two median plications the strongest, the lateral ones becoming successively smaller towards the cardinal extremities, the outermost ones sometimes becoming almost obsolete.

Brachial valve more uniformly convex than the pedicle, the greatest depth near the middle, usually slightly compressed towards the cardinal extremities; the beak incurved and coming in contact with the basal margin of the pseudodeltidium; plications alternate with those of the opposite valve and entirely similar to them.

In addition to the plications both valves are marked by concentric lines of growth of variable strength and distribution. Shell structure minutely punctate.

Remarks.—This species is rather widespread in its geographical distribution in the Mississippi valley, in the faunas of the late Kinderhook, and perhaps passes over into the Burlington limestone. It may be easily recognized by its strong plications, and is not closely similar to any other shell in these faunas. It is rather variable in several particulars, especially in the convexity of the valves and consequent globosity of the shell, and in the number of plications. Because of its variability the species has been described under several names, but a careful examination of as many specimens as possible has led to the conclusion that the differences observed are not constant and are not even of varietal importance, and that all the forms belong to a single species.

Horizon.—Kinderhook.

Genus *EUMETRIA* Hall

Description.—Shells small or of medium size, subovate in outline, the hinge-line very short, the valves subequally convex, marked by fine, simple, rounded or subangular radiating plications. Shell structure very minutely and closely punctate. Pedicle valve with a prominent, incurved umbo, perforated at its apex by a large, subcircular foramen which is in contact with the delthyrium only at its apex; the cardinal area small, but sharply defined, its lateral margins abruptly elevated above the surface of the valve on either side, the delthyrium occupying the greater part of the area, closed by the pseudodeltidium. Internally the hinge-teeth are of moderate size, not supported by dental lamellæ, the muscular impressions inconspicuous, being only rarely sufficiently impressed to leave any suggestion whatever of their presence. Brachial valve with the cardinal extremities usually compressed to form minute auriculations; internally the hinge-plate is a complicated structure consisting of a posterior and an anterior part, extending in opposite directions from the central portion, which joins the two socket walls, the posterior part consists of a crescentic process whose horns make nearly a semi-circle and extend backward into the umbonal region of the pedicle valve, the concave margin of the crescent lying against the inner surface of the pseudodeltidium of the opposite valve, the tips of the crescent raised away from the inner surface of the shell. The anterior part of the hinge-plate is connected with the median part by a narrow, thickened, median band; it consists of a long, narrow, concave or spoon-shaped central process with sharply elevated edges, these marginal ridges being produced anteriorly into the two elongate, slender, and nearly vertical crura, the whole being supported by two slightly divergent, upright lamellæ which extend to the floor of the valve. The spiral cones approximate, with eight or nine volutions, the apices directed laterally, the jugum posterior in position, regularly curved from the points of origin on the primary lamellæ anteriorly and towards the interior, from its central point a process, bifid at the extremity, extends towards and nearly to the extremities of the crura. No muscular markings have been observed in this valve.

Remarks.—The true relations of this genus to *Acambona* have not been cleared up, and because of the rarity of examples of the genotype of *Acambona,* it may be a long time before the relationships of the two genera can be determined. There are no characters present in the holotype of *Acambona prima,* the genotype of that genus, which can exclude the shell from *Eumetria.*

Eumetria altirostris (White)

Plate LXXVI, Figs. 7-11

1862. *Retzia (Acambona?) altirostris* White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 28.

1897. *Eumetria (?) altirostris* Schuchert, Synop. Am. Foss. Brach., p. 222.

1900. *Eumetria altirostris* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 74, pl. 2, figs. 18-19.

Description.—Shell of medium size or smaller, subovate in outline, longer than wide, the greatest width anterior to the middle, the lateral margins diverging in nearly straight lines from the beak to nearly the line of greatest width, the anterior and antero-lateral margins describing a nearly semicircular curve, the hinge-line very short. The dimensions of a nearly complete, large individual are: length of pedicle valve 23.5 mm., length of brachial valve 20 mm., greatest width 20.5 mm., thickness 14 mm., length of hinge-line ±5 mm.

Pedicle valve most convex posterior to the middle, the umbonal region prominent and projecting notably beyond the hinge-line, the median line of the valve arcuate or curving with a gradually decreasing curvature from the beak to the front, the surface curving rather abruptly from the median portion of the valve to the lateral margins, and posteriorly inflected towards the cardinal extremities; the beak prominent, pointed and incurved, and pierced by a large, subcircular foramen which encroaches upon the umbonal region of the valve; the cardinal area small and arched, its lateral margins sharply defined, sloping regularly from the sides of the beak to the cardinal extremities; in the median portion of the valve the surface is flattened along an indefinite band extending from the umbonal region to the front, and is sometimes depressed to form a shallow, ill-defined median sinus; the surface of the valve is marked by from 19 to 21 simple, depressed, rounded plications which increase gradually in size in passing from the beak to the margin, sometimes a plication much narrower than those on either side is intercalated along the median line at near the mid-length of the shell, and continues to the front margin.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the beak extending a little beyond the hinge-line posteriorly, the surface curving abruptly from the umbonal region to the cardinal and postero-lateral margins, the median portion sometimes a little flattened along an indefinite band extending from the middle of the shell to the anterior margin, but never elevated into a distinct mesial fold; the surface marked by plications similar in form and number to those of the opposite valve.

The shell structure is probably punctate, although this cannot be determined from any of the specimens examined.

Remarks.—The minute surface markings and the shell structure of this species cannot be determined from any of the specimens which have been examined, because of their condition of preservation as more or less modified casts in a fine-grained sandstone. In a few cases some more or less indefinite, concentric lines of growth are retained, but for the most part the specimens are essentially smooth, aside from the plications. Neither the characters of the brachidium nor the peculiar characters of the hinge of *Eumetria* have been observed in this species, and unless individuals in a different condition of preservation than those at hand are secured at some future time, there can be no hope of certainly determining the generic relations of the species. So far as external form, the characters of the beak, and the characters of the cardinal area go, there is no fundamental difference between this shell and the true species of *Eumetria* from a higher horizon. The characteristic features of this species are found in the broad plications, which are less in number than in any other species except *E. acuticosta*, but which differ from that species in being flat and rounded instead of acutely angular; the shell also has a greater tendency to develop an undefined mesial sinus in the pedicle valve than any of the other species, and the shell is usually somewhat more pointed posteriorly. The small, intercalated, median plication which is sometimes present in specimens of this species is also a character different from that in any of the other species.

The relationship of this species to the genus *Acambona*, and indeed the relationship of the genus *Eumetria* to *Acambona*, is quite uncertain. Externally the two genera are essentially alike, and although some of the internal characters of *Acambona* have been described as being entirely different from similar parts of *Eumetria*, yet authentic specimens of *Acambona* are so rare that it is most difficult to secure material from which to really determine its essential characters, and it is not yet entirely certain that the structures in *Acambona* have been correctly interpreted, or that there is really an essential generic difference between it and *Eumetria*. If these two genera should at some future time be proven to be synonymous, the name *Eumetria* would have to give place to *Acambona* which has several years priority.

Horizon.—Chonopectus sandstone of the Kinderhook.

Eumetria osagensis (Swallow)

Plate LXXVI, Fig. 12

1860. *Retzia osagensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 653.
1894. *Eumetria? osagensis* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 7-9.

1894. *Retzia ? osagensis* Keyes, Mo. Geol. Surv., vol. 5, p. 94.
1895. *Acambona ? osagensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 38, 39.

Description.—Shell of medium size, longer than wide, the hinge-line very short, subovate in outline, the greatest width anterior to the middle of the shell, the lateral margins diverging from the beak in nearly straight lines almost to the line of greatest width of the shell, the anterior and antero-lateral margins describing a nearly semicircular curve. The dimensions of the type specimen as given by Swallow are: length 30.5 mm., width 23.8 mm., thickness 18.8 mm. The dimensions of an imperfect, somewhat crushed example are: length of pedicle valve 23 mm., length of brachial valve 20 mm., greatest width 21.5 mm.

Brachial valve most convex posterior to the middle, the umbo prominent and projecting notably beyond the hinge-line, the surface of the valve arched from beak to front along the median line, somewhat flattened towards the front, the curvature of the surface from the umbonal region towards the postero-lateral margins is rather abrupt, towards the cardinal extremities becoming inflected; the beak is prominent and incurved, and is perforated by a large, circular foramen which encroaches upon the umbonal region; the cardinal area is small and arched, its lateral margins are defined and slope from the sides of the beak to the cardinal extremities.

Brachial valve less convex than the pedicle, the greatest convexity posterior to the middle, the beak somewhat projecting beyond the hinge-line, the surface curving abruptly from the umbonal region to the cardinal extremities and to the postero-lateral margins, the curvature more gentle anteriorly and antero-laterally.

Each valve marked by about 50 fine, simple, flattened, radiating plications separated by narrow grooves. The shell structure minutely and finely punctate.

Remarks.—This is an exceedingly rare shell in the Chouteau limestone, and only a single, imperfect, and somewhat crushed specimen has come under the observation of the writer. It is essentially impossible to point out any characters by which the species can be separated from *E. verneuiliana* or *E. vera*. The number of plications being about 50 is perhaps more nearly like *E. verneuiliana*, but the apparent shape of the shell, with its greatest width in front of the middle, is more like *E. vera*. Upon the specimen which has been studied the plications of the shell are apparently more sharply marked upon the exfoliated portions of the surface, and upon one small area, which is apparently in its natural condition, no plications are discernable. It is possible that this may prove to be an essential feature of the species, but to determine this the examination of more material is desirable.

The reference of this species to the genus *Eumetria* may be incorrect, but there is no way to determine from the material available whether it is a member of this genus or of *Acambona*. It has been referred to both genera in the past, but never upon sufficiently well founded evidence.

Horizon.—Chouteau limestone.

Eumetria perstrialis Rowley

Plate LXXVI, Figs. 4-6

1900. *Eumetria perstrialis* Rowley, Am. Geol., vol. 25, p. 266, pl. 5, figs. 28-30.

Description.—Shell small, longer than wide, ovate-subcuneate in outline, the greatest width anterior to the mid-length, the long postero-lateral margins nearly straight and meeting at the beak in an angle of about 57 degrees, the antero-lateral margins regularly rounded into the less curved, subtruncate anterior margin. The dimensions of the holotype are: length of pedicle valve 10 mm., length of brachial valve 8.9 mm., greatest width 7.2 mm., thickness 6 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the point of greatest convexity to the postero-lateral margins and becoming a little inflected to the cardinal extremities, curving with a long, gently convex slope to the anterior margin and with a shorter, more strongly convex curvature to the beak; mesial sinus or fold obsolete; the beak rather large and prominent, projecting notably beyond that of the opposite valve, pierced by a large foramen which encroaches upon the umbonal region of the valve, the delthyrium closed by deltidial plates; cardinal area very small, scarcely greater than the delthyrium.

Brachial valve with its greatest convexity posterior to the middle, the surface curving abruptly to the postero-lateral margins, sloping with a long, gently convex curvature to the anterior margin and with a shorter and more strongly convex curvature to the beak; mesial fold or sinus obsolete; the beak rather strongly incurved beneath the pseudodeltidium of the opposite valve.

Surface of both valves marked by fine, simple, radiating plications, three or four of which occupy the space of one millimeter at the front of the shell, the entire number recognizable being about 42, in the posterior half of the shell these plications become so fine that the shell appears to be smooth except when examined under a lens. A little posterior to the middle a rather strong line of growth marks each valve in the holotype, with a somewhat smaller line between it and the umbo, other concentric markings obsolete.

Remarks.—A single example of this species, the holotype, has been examined. Its internal characters are unknown so it is not possible to determine whether or not it possesses the essential characters of *Eumetria* or

of *Acambona*, if these two genera should prove to be distinct. It differs from all other species of *Eumetria* in its more narrowly ovate outline, and in its exceedingly fine radiating plications. In these characters it much more closely resembles *Acambona prima*, indeed, in all essential features it has every appearance of being a diminutive example of that species, and it should perhaps be so considered. The satisfactory interpretation of these rare forms, however, must be deferred until more abundant material is available for study.

Horizon.—Lower Burlington white chert.

Eumetria verneuilana (Hall)

Plate LXXVI, Figs. 18-24

1852. *Terebratula serpentaria* ? Owen, Geol. Rep. Wis., Iowa and Minn., tab. 3A, fig. 13.
1856. *Retzia Verneuilana* Hall, Trans. Albany Inst., vol. 4, p. 9.
1858. *Retzia verneuilana* Hall, Geol. Iowa, vol. 1, pt. 2, p. 657, pl. 23, figs. 1a-d.
1882. *Eumetria Verneuilana* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 50, pl. 6, figs. 28-30.
1883. *Eumetria verneuiliana* Hall, 12th Rep. Geol. Surv. Ind., p. 335, pl. 29, figs. 28-30.
1884. *Retzia Verneuiliana* Walcott, Pal. Eureka Dist., p. 220, pl. 7, figs. 5-5a.
1894. *Eumetria Verneuiliana* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 1-4, 6, 10.
1894. *Retzia verneuiliana* Keyes, Mo. Geol. Surv., vol. 5, p. 95.
1895. *Eumetria Verneuiliana* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 13-26, 34, 35; pl. 83, figs. 26-27.
1897. *Eumetria verneuilana* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 259.
1899. *Eumetria verneuiliana* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 560, pl. 68, figs. 12a-b.
1903. *Eumetria marcyi?* Girty, U. S. Geol. Survey, Prof. Paper, No. 16, p 303.
1904. *Eumetria marcyi* Girty, Prof. Paper U. S. Geol. Survey, No. 21, p 49, pl. 10, figs. 15-17.
1906. *Eumetria marcyi* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1319, pl. 22, figs. 28-30.
1911. *Eumetria marcyi* Girty, Bull. U. S. Geol. Survey, No. 439, p. 77, pl. 8, fig. 10.
1911. *Eumetria marcyi* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 386, fig. 14.

Description.—Shell small, longer than wide, the greatest width near the mid-length of the shell, ovate in outline, the lateral margins diverging from the beak at varying angles in nearly straight lines or with slightly convex curvature to the line of greatest width of the shell, in front of this line the outline is subsemicircular with sometimes a slight straightening or truncation of the margin at the anterior extremity, the hinge-line

very short. The dimensions of two individuals are: length of pedicle valve 19 mm. and 21 mm., length of brachial valve 16 mm. and 18 mm., greatest width 18 mm. and 19 mm., thickness 11 mm. and 14 mm., length of hinge-line 5 mm. and 5 mm.

Pedicle valve more or less strongly convex, the greatest convexity posterior to the middle, the umbonal region prominent and projecting notably beyond the hinge-line, the surface curving from the umbonal region to the anterior with a regularly decreasing convexity, laterally the curvature becomes more abrupt towards the cardinal extremities; towards the cardinal margin the surface is inflected and not infrequently slightly auriculate at the cardinal extremities; the beak is pointed, strongly incurved, and is pierced by a large, subcircular foramen which encroaches notably upon the umbonal region, only the margin of it occupying the apical portion of the delthyrium; the cardinal area is very small, arched, the lateral margins usually sharply defined and sloping in nearly straight lines from the sides of the beak to the cardinal extremities, the delthyrium closed by a pseudodeltidium; the mesial sinus is obsolete, but in some individuals there is a slight, indefinite flattening in the anterior median portion of the valve.

Brachial valve a little less convex than the pedicle, the greatest convexity posterior to the middle; the beak pointed and very slightly projecting beyond the hinge-line; the surface curving from the beak to the anterior margin with gradually lessening curvature, laterally the curvature becomes more abrupt towards the cardinal extremities where the surface is compressed to form small auriculations which are larger than those of the pedicle valve; along the median portion of the valve the surface is slightly and indefinitely flattened towards the front of the shell, but no mesial fold is developed, the flattening, however, is usually more marked than that of the pedicle valve.

The surface of both valves is marked by fine, simple, rounded, nearly uniform, radiating plications, separated by furrows narrower than the plications themselves; each valve bears from 42 to 55 of these plications, the more usual number being between 46 and 50. The shell structure is minutely punctate.

Remarks.—This species exhibits great variation in size, in the proportional dimensions of length and width, and in the convexity of the valves. Some examples attain a larger size than either of those whose dimensions have been given above; a smaller size is the more usual, however, although the specimens exhibit the characteristics of adult shells. Occasionally the valves become strongly ventricose, especially in old individuals.

In his bibliographic list Schuchert[1] has included this form as well as *E. vera* Hall and *E. vera* var. *costata* Hall, as synonyms under *E. marcyi*

[1] Bull. U. S. Geol. Survey, No. 87, p. 222. (1897.)

Shumard. The originals of Shumard's species were from Washington and Crawford Counties, Arkansas, and have evidently been lost, and his illustrations are so imperfect that they can scarcely be recognized. The only tangible character mentioned in the original description is the number of plications, which are stated to be from 34 to 38 upon each valve, a number which would correspond with examples of *E. costata*. If these different forms are recognized as distinct, as is done here, Shumard's name cannot be considered as having priority over *E. vernenilliana*, and if used at all must be used as a substitute for *E. costata*. Considering the uncertainty which must exist in the absence of the type specimens, as to what *E. marcyi* really is, it seems best to drop that name altogether and to use the names applied by Hall, which were clearly defined and were illustrated by excellent figures.

Horizon.—Salem limestone; St. Louis limestone; Chester group.

Eumetria vera (Hall)

Plate LXXVI, Figs. 13-17

1858. *Retzia vera* Hall, Geol. Iowa, vol. 1, pt. 2, p. 704, pl. 27, fig. 3a.
1894. *Eumetria vera* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 8, 12.
1894. *Retzia vera* Keyes, Mo. Geol. Surv., vol. 5, p. 95.
1895. *Eumetria vera* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 36, 37.
1909. *Eumetria marcyi* Bassler, Va. Geol. Surv., Bull. No. II A., pl. 29, figs. 4-5.

Description.—Shell of medium size, longer than wide, the greatest width anterior to the mid-length of the shell, subovate in outline, the sides diverging from the beak anteriorly in nearly straight or slightly convex lines to the line of greatest breadth, anteriorly the outline is subsemicircular, often with a slight straightening of the anterior margin, the hinge-line very short. The dimensions of three individuals are: length of pedicle valve 25.5 mm., 20 mm. and 19 mm., length of brachial valve 23.5 mm., 17 mm. and 17 mm., greatest width 26 mm., 19 mm. and 16 mm., thickness 16 mm., 11 mm. and 10 mm., length of hinge-line 6.5 mm., 5.5 mm. and ±4.5 mm.

Pedicle valve most convex posterior to the middle, the umbonal region prominent and projecting posteriorly beyond the hinge-line, the surface curving with a regularly diminishing curvature from the beak to the anterior margin, the curvature gradually becoming more abrupt anteriorly along the lateral margins, and towards the cardinal extremities becoming inflected, at the cardinal extremities the surface is again slightly deflected to form a pair of minute auriculations which are sometimes nearly or quite obsolete; the beak is large, prominent and incurved, and is pierced by a large circular foramen which encroaches notably

upon the umbonal region, only the margin of it being in contact with the delthyrium; cardinal area small, arched, the lateral margins sharply defined, sloping from the sides of the beak in nearly straight lines to the cardinal extremities, the delthyrium closed by a pseudodeltidium; median portion of the valve not depressed in a sinus but sometimes slightly flattened along an indefinite mesial band.

Brachial valve a little less convex than the pedicle, the greatest convexity posterior to the middle, the beak extending slightly beyond the hinge-line posteriorly, the surface curving rather abruptly from the umbonal region towards the cardinal extremities, but before reaching the margin it is deflected to form a pair of small, nearly flat auriculations a little more conspicuous than those of the opposite valve, forward from the cardinal extremities along the lateral margins to the anterior margin the curvature becomes gradually more gentle; the median portion of the valve is sometimes slightly flattened along an indefinite mesial band but is not elevated in a fold.

Both valves are marked by regular, simple, rounded, nearly uniform, radiating plications which are so fine as to be almost indistinguishable at the beak, but increase gradually in strength with the growth of the shell. The number of these plications is usually between 42 and 48 on each valve. Lines of growth are inconspicuous or wanting. The shell structure minutely punctate.

Remarks.—This species is closely allied to *E. verneuilana* and has sometimes been considered as a synonym of that species. There seem to be some reasons, however, for its recognition under a distinct name, but whether this designation should be considered as of specific or varietal rank is largely a matter of personal opinion. There seems to the writer to be little utility in using three names to distinguish a certain form, and if it has characters sufficiently distinct to allow its being separated from another, it seems worth while to designate it by a specific name. *Eumetria vera* differs from *E. verneuilana* in attaining a larger size, in having a somewhat smaller maximum number of plications, and in the more anterior position of the greatest width of the shell. In addition to these characters, no examples have been observed to attain so great a convexity as is sometimes developed in *E. verneuilana*.

Horizon.—Chester group.

Eumetria costata (Hall)

Plate LXXVI, Figs. 25-29

1858. *Retzia vera* var. *costata* Hall, Geol. Iowa, vol. 1, pt. 2, p. 704, pl. 27, figs. 3a-b.

1894. *Eumetria vera* var. *costata* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 5, 11.

1895. *Eumetria vera* var. *costata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 27-33.

Description.—Shell attaining a medium size, longer than wide, the hinge-line very short, the greatest width anterior to the middle, subovate in outline, the lateral margins diverging from the beaks nearly to the line of greatest width in straight or slightly convex lines, anteriorly the outline is subsemicircular, sometimes with a slight straightening of the margin in the center. The dimensions of two individuals are: length of pedicle valve 30 mm. and 27 mm., length of brachial valve 26 mm. and 23.5 mm., greatest width 28 mm. and 23 mm., thickness 16 mm. and 15 mm., length of hinge-line 6 mm. and 7 mm.

Pedicle valve most convex posterior to the middle, the umbonal region projecting notably beyond the hinge-line; the curvature of the surface from the beak to the anterior margin has a regularly decreasing convexity, the convexity to the lateral margins becoming gradually more abrupt anteriorly; towards the cardinal extremities the surface is inflected, and at the cardinal extremities the surface is again deflected to form a pair of minute, sometimes almost obsolete, auriculations; the beak is prominent and incurved, and is pierced by the large, subcircular foramen, which encroaches notably upon the umbonal region; the cardinal area small, arched, its lateral margins sharply defined, sloping regularly from the sides of the beak to the cardinal extremities, the delthyrium closed by the pseudo-deltidium, only its apex being in contact with the foramen; mesial portion of the valve not depressed in a sinus, but sometimes the surface of the valve is flattened along an undefined mesial band, especially towards the front.

Brachial valve a little less convex than the pedicle, the greatest convexity posterior to the middle, the beak projecting slightly beyond the hinge-line, the surface curving somewhat abruptly from the umbonal region towards the cardinal extremities, but again deflected just before it reaches these extremities to form a pair of small auriculations a little more conspicuous than those of the pedicle valve; anteriorly from the beak to the front of the valve the surface describes a gradually decreasing convex curve and laterally the curvature becomes gradually more convex in passing from the anterior margin towards the hinge extremities.

Each valve is marked by from 30 to 40 regular, simple, depressed, rounded, nearly uniform, radiating plications, which increase regularly in size in passing from the beak to the front. Growth lines are either lacking or are inconspicuous. The shell structure is minutely punctate.

Remarks.—This shell was originally described as a variety of *E. vera*, and has sometimes been considered along with that species, as synonymous with *E. verneuilana*. It is not improbable that all of these forms might be shown to be united by intergradations, yet it seems advisable

to retain their separate names as applied by Hall, considering *costata* as of equal rank with the others, however, and not as a variety under *E. vera*. Each form possesses its individual characteristics and the number of individuals possessing those characteristics is much greater than those with intermediate characters. *E. costata*, perhaps, attains a larger size than any of the others, but in general outline it is not essentially different from *E. vera*, having its greatest width anterior to the middle of the shell. The distinctive feature of the form is its coarser plications, about 35 being nearly the normal number, while the other two species, although usually smaller shells, have usually 45 or more plications.

Horizon.—Chester group.

Eumetria acuticosta n. sp.

Plate LXXVI, Figs. 30-34

Description.—Shell small, hinge-line very short, length and breadth nearly equal, the greatest width near the mid-length of the shell, the lateral margins diverging from the beak anteriorly nearly to the line of greatest width of the shell, the anterior and antero-lateral margins subsemicircular. The dimensions of a perfect specimen are: length of pedicle valve 16.3 mm., length of brachial valve 14 mm., greatest width 16 mm., thickness 10.5 mm., length of hinge-line 4 mm.

Pedicle valve most convex posterior to the middle, the umbo prominent and projecting notably beyond the hinge-line, the surface curving from the beak to the anterior margin with a regularly decreasing convex curvature, towards the lateral margins the curvature becomes gradually more abrupt in passing from the anterior margin posteriorly; towards the cardinal extremities the surface becomes inflected and at the cardinal extremities it is again deflected to form a pair of minute auriculations; the beak is prominent, incurved, and is pierced by a large, circular foramen which encroaches upon the umbonal region; the cardinal area small, arched, sharply defined, the cardinal margins sloping regularly from the sides of the beak to the cardinal extremities; the valve is without median sinus, the median portion not even being flattened as it is in some members of the genus.

Brachial valve subequally convex with the pedicle, the greatest convexity posterior to the middle, the beak projecting slightly beyond the hinge-line, the surface curving rather abruptly from the umbonal region towards the cardinal margin, the curvature becoming gradually more gentle in passing anteriorly along the lateral margins to the anterior extremity, along the median line of the valve from the beak anteriorly, the surface describes a regularly diminishing convex curve, at the cardinal extremities the surface of the valve is deflected to form a pair of minute auriculations.

Each valve is marked by about 22 sharply angular, nearly uniform simple, radiating plications which increase gradually in size in passing from the beak towards the margin. Conspicuous growth lines are obsolete upon the type specimen, but exceedingly minute, concentric striæ may be detected upon some portions of the shell. The shell structure is minutely punctate.

Remarks.—This species differs primarily from the other recognized members of the genus in its much coarser and deeper, strongly angular plications. The shell is also proportionally broader than is usually the case with individuals of other species, it being nearly equal in length and breadth.

Horizon.—Chester group.

Genus *ACAMBONA* White

Description.—Shells of medium size or larger, subovate in outline, the hinge-line very short, the valves subequally convex, marked by fine, rounded, simple plications, the shell structure minutely and closely punctate. Pedicle valve with a small cardinal area having its lateral margins sharply defined and elevated above the surface of the valve on either side, the delthyrium occupying nearly the entire cardinal area, closed by the pseudodeltidium; the foramen large, subcircular, encroaching wholly upon the umbonal region of the valve. Internally, dental lamellæ are apparently absent, no other internal characters recognizable in the genotype except the presence of a spiral brachidium. The brachial valve slightly compressed at the cardinal extremities to form minute auriculations, the internal characters not preserved in the genotype.

Remarks.—The essential generic characters of the holotype of *A. prima*, the genotype of *Acambona*, are not preserved, and so far as this specimen is concerned, there is no reason for placing it in any genus other than *Eumetria*. Hall and Clarke[1] have stated, however, that members of the species *A. prima* bear "an internal pedicle-tube, as in *Retzia* and *Hustedia*, a character absent in *Eumetria*." Specimens of this species are exceedingly rare and only the holotype has been available to the writer for study, and no such pedicle-tube is visible in that specimen, although it may be present. Until further information concerning the genus can be secured it seems best to allow it to stand with the genotype as the single representative, although if it is really a good genus, it is possible that some of the species here placed in *Eumetria* may be eventually transferred to it.

[1] Pal. N. Y., vol. 8, pt. 2, p. 119. (1894.)

ACAMBONA PRIMA White

Plate LXXVI, Figs. 1-3

1862. *Acambona prima* White, Proc, Boston Soc. Nat. Hist., vol. 9. p. 27, figs. 1-2.

(?) 1894. *Acambona prima* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 21-22.

(?) 1895. *Acambona prima* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 40-41.

Description.—Shell above medium size, subovate in outline, longer than wide, the greatest width at about the mid-length, the hinge-line very short, the anterior and antero-lateral margins regularly rounded, the postero-lateral margins nearly straight or slightly convex, meeting, when projected beyond the beak, in an angle of about 67 degrees. The dimensions of the holotype, a somewhat imperfect and distorted specimen, are: length of pedicle valve 40 mm., length of brachial valve 35 mm., greatest width 27.8 mm., thickness ±21 mm.

Pedicle valve with its greatest convexity posterior to the middle, apparently about half way between the middle and the beak, the median portion of the valve gently convex transversely, the surface becoming more abruptly convex as it approaches the lateral margins, and becoming incurved to the cardinal extremities and to the postero-lateral margins; mesial sinus wanting; cardinal area very small, scarcely reaching beyond the limits of the delthyrium, sharply defined laterally, its lateral margins sharply elevated from the postero-lateral slopes of the valve, concave with the curvature increasing towards the beak, the delthyrium closed by a pseudodeltidium in its upper part, the lower portion occupied by the beak of the opposite valve; the beak sharply pointed and strongly incurved, the foramen apparently large and encroaching entirely upon the umbonal portion of the valve, not in contact with the delthyrium even at its apex.

Brachial valve apparently about equally convex with the pedicle, with the greatest convexity near or posterior to the middle, the surface curving rather abruptly to the postero-lateral margins, less abruptly to the lateral and more gently to the anterior margin, compressed at the cardinal extremities to form minute alations; mesial fold or sinus wanting; beak pointed and incurved beneath the margin of the pseudodeltidium of the opposite valve and filling the lower portion of the delthyrium of that valve.

Surface of each valve marked by about 90 simple, depressed, rounded, radiating plications which become obsolete on the umbonal portion of the valves, being clearly defined, indeed, only in the anterior half of each valve, not over fifty of the plications are conspicuous, about 20 on each

side along the postero-lateral margins being very faint and difficult to distinguish, the largest plications at the front margin measure about 1 mm. from center to center. The plications are crossed by concentric lines of growth, several of which in the anterior half of the shell, are strongly marked and wrinkle-like in the type. The shell substance punctate.

Remarks.—The present description of this species has been based upon the holotype now preserved in the White Collection at the University of Michigan, the only example to come under the observation of the writer. In the original definition of the genus *Acambona* no mention of a foramen in the pedicle valve is made, and no indication of such an opening is shown in the illustration of the shell, and this supposed imperforate condition of this valve was evidently the character upon which the genus was primarily based. The type specimen shows a large opening in the umbonal portion of the pedicle valve just back of the beak which is believed to be, without doubt, a large foramen. The margins of this opening, however, are irregular and indicate a broken condition except for a short distance where the natural border of the foramen is clearly present; because of this condition, White evidently interpreted it as an accidental fracture of the shell. The remarkable degree of encroachment of the foramen upon the umbonal region of the valve, so that it is entirely out of contact with the apex of the delthyrium, thus allowing the apex of the beak to remain sharply pointed, was probably another reason for White's interpretation of the opening as an accidental break. With the elimination of the imperforate beak of the pedicle valve, there remains no external character of more than specific value to separate this shell from members of the genus *Eumetria*. It has been shown by Hall and Clarke,[1] however, that a calcareous pedicle tube upon the inner surface of the pseudodeltidium, such as is present in *Retzia* and *Hustedia*, is wanting in *Eumetria*, and it is stated by these same authors[2] that such a structure is present in *Acambona prima*. Hall and Clarke, however, had apparently never studied the holotype of the species, and a careful examination of this specimen has failed to demonstrate either the presence or the absence of such a structure; under the circumstances the status of the genus *Acambona* must remain doubtful. If there is no pedicle tube present, it is altogether likely that this species is not generically different from the shells included in *Eumetria*, in which case the name *Acambona* must take precedence over *Eumetria*, having been proposed by White in 1862, one year previous to the first usage of *Eumetria* by Hall. But if a pedicle tube is really present, the genus is doubtless a good one. Because of the extreme rarity of examples of the species, it may be long before its true relations can be satisfactorily established, but for the

[1] Pal. N. Y., vol. 8, pt. 2, pp. 115-119. (1895.)
[2] Loc. cit., p. 119.

present it seems best to retain the genus with the genotype as the only representative.

Horizon.—Burlington limestone

Genus *HUSTEDIA* Hall

Description.—Shells small, subovate in outline, with nearly equally convex valves, marked by rather coarse, subangular, simple plications, the shell structure punctate. Pedicle valve with a prominent umbo perforated at its apex by a subcircular foramen, cardinal area small, with sharply defined lateral margins, the delthyrium closed by the pseudodeltidium and in contact with the foramen only at its apex. Internally the inner surface of the pseudodeltidium bears a split tube attached by its closed side to the deltidial plates, with its open side directed towards the interior of the shell. In the brachial valve the hinge-plate projects considerably beyond the hinge-line posteriorly, being recurved into the umbonal cavity of the pedicle valve, the upper face is convex and elevated medially, the posterior margin sinuate and crescentic with the horns of crescent very short, from the lateral margins of the plate arise a pair of strong lobes which bear the erect, slightly recurved crura. At the base of the cardinal process and in the median line, there arises a free, slender, ligulate process which curves upward and backward with a somewhat less curvature than the hinge-plate, and rises to the highest point attained by the latter; the inner surface of this process is deeply grooved and at its base it is supported by a median septum which extends for one-third the length of the valve. The spiral cones of the brachidium and the jugum are similar to those of *Eumetria*, but the posterior margins of the coils and the jugum are fimbriated, and the extremity of the stem-like process from the jugum is apparently simple.

Remarks.—The genotype of *Hustedia* is the Pennsylvanian shell *H. mormoni*, and the description of the internal characters of that shell, given above, has been taken from the work of Hall and Clarke. Externally these shells differ from *Eumetria* only in their smaller size and coarser plications. The internal characters of *H. circularis* of this report have never been determined, and the species is placed in the genus *Hustedia* only because of its external resemblance to the genotype.

HUSTEDIA CIRCULARIS (Miller)

Plate LXXVI, Figs. 47-52

1892. *Retzia circularis* Miller, Adv. Sheets 18th Rep. Geol. Surv. Ind., p. 62, pl. 9, figs. 32-34.

1894. *Retzia circularis* Miller, 18th Rep. Geol. Surv. Ind., p. 316, pl. 9, figs. 32-34.

1909. *Retzia circularis ?* Weller, Bull. Geol. Soc. Am., vol. 20, p. 317, pl. 12, fig. 23.

Description.—Shell very small, subglobular, ovate in outline, the cardinal extremities not differentiated from the general curvature of the outline, the greatest width near the mid-length, the hinge-line short, about two-fifths the greatest width of the shell. The dimensions of a very perfect specimen of about average size are: length of pedicle valve 5.5 mm., length of brachial valve 4.9 mm., greatest width 5 mm., thickness 3.7 mm., length of hinge-line 2 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the postero-lateral margins and becoming a little incurved towards the beak, curving more gently to the antero-lateral and anterior margins; mesial sinus obsolete; beak moderately incurved, not coming in contact with the umbo of the opposite valve, perforated by a circular foramen which encroaches upon the umbonal portion of the valve; cardinal area small, concave, with the curvature increasing towards the beak, the inferior, flatter portion lying nearly in the plane of the valve, the lateral margins rather sharply defined; the delthyrium closed by the pseudodeltidium which can scarcely be distinguished from the general surface of the cardinal area. Surface of the valve marked by about sixteen simple, rounded plications, which reach to the beak; they are strongest in the middle of the valve and become fainter towards the cardinal extremities; the concentric markings faint or obsolete.

Brachial valve subcircular in outline, about equally convex with the pedicle, the greatest convexity posterior to the middle, the surface curving from the highest point rather abruptly to the cardinal margin, becoming slightly compressed towards the cardinal extremities, the curvature to the antero-lateral and anterior margins more gentle; on the median line the surface is slightly and narrowly depressed in the umbonal region, the depression being nearly or quite obsolete anterior to the middle; the beak pointed and rather strongly incurved. Surface marked by plications entirely similar to those of the opposite valve and alternating with them, the median plication, however, does not reach the beak but originates in the slight median depression of the valve in the umbonal region; concentric markings like those of the opposite valve.

Remarks.—Material for the investigation of the internal characters of this little shell has not been available, and consequently the generic reference of the species cannot be made with entire certainty. Judging from external characters alone, however, the species has its nearest ally in *Hustedia mormoni* of the Pennsylvanian faunas, the genotype of *Hustedia,* and because of this the present species is placed in that genus. This species is smaller than *H. mormoni,* with relatively finer and less angular plications, and it is proportionally shorter than the average specimens of that species.

Horizon.—Choutean limestone.

Family MERISTELLIDÆ

Genus *NUCLEOSPIRA* Hall

Description.—Shells small, subcircular in outline, the valves subequally convex, the hinge-line very short, the cardinal extremities rounded, the mesial sinus of the pedicle valve and the fold of the brachial valve low and ill-defined, usually obsolete except near the anterior margin. The epidermal layer usually, if not always, covered with numerous, closely crowded, fine, short spinules. Pedicle valve with a very low and small cardinal area which is obscured in mature shells by the incurvature of the beak, the delthyrium closed by a pseudodeltidium. Internally the hinge-teeth are prominent, approximate, recurved at the tips and supported by thickened bases but not by dental lamellæ; the muscular area rather large and flabellate, not sharply defined about its margins, divided longitudinally by a low but distinct median septum which extends nearly to the front margin of the valve. In the brachial valve the cardinal process and hinge-plate combined rises nearly vertically from the bottom of the valve, but just above the plane of the margins of the valve it is abruptly bent posteriorly so that its upper surface is nearly parallel with the plane of the valve and is extended beyond the margin of the valve posteriorly into the umbonal cavity of the pedicle valve; the crural bases are situated on the vertical face of the plate at the point of recurvature, the crura are straight and slender with a length equal to one-fourth the length of the shell; the primary lamellæ of the brachidium are greatly incurved, the spires are made up of from six to ten volutions, their apices directed transversely; the jugum originates at about one-fourth the length of the lamellæ, it is inclined slightly backward, the lateral branches are united and produced into a straight, elongate, undivided stem. The muscular scars are narrow and elongate, ill-defined and are divided by a median septum similar to that of the pedicle valve.

Remarks.—The members of this genus are usually easy to recognize from their external form, viz, the subcircular and nearly equally convex non-plicated valves. In internal casts they may be easily recognized by the form of the shell and by the presence of the elongate median septum in the condition of a median slit, extending nearly to the front of each valve. The minute surface spines of members of the genus are commonly destroyed in the fossil specimens, but their former presence often may be determined by the presence of the minute papillæ-like bases of the spines.

Nucleospira rowleyi n. sp.

Plate LXXXII, Figs. 43-48

1901. *Nucleospira barrisi* Rowley, Am. Geol., vol. 27, p. 350, pl. 28, figs. 46-48. (Not *N. barrisi* White).

1908. *Nucleospira barrisi* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 85, pl. 18, figs. 25-27.

Description.—Shell small, lenticular, usually a little wider than long, subcircular or transversely subelliptical in outline, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of a nearly perfect example are: length of pedicle valve 4.5 mm., length of brachial valve 4.1 mm., greatest width 5 mm., thickness 3 mm., length of hinge-line 2.3 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the cardinal margin, and more gently to the lateral and anterior margins; mesial sinus originating in the umbonal region near the beak, very shallow, rather broad, not sharply defined at any point but becoming more ill-defined anteriorly; beak short and obtuse, but slightly incurved; cardinal area small, concave, the lateral margins defined by a slight angularity of the surface separating the surface of the lateral slopes of the valve from that of the cardinal area. Surface of the valve apparently smooth or marked only by obscure concentric lines of growth, in most individuals, but in the best preserved examples the presence of numerous, minute, crowded, appressed spines is shown.

Brachial valve a little less convex than the pedicle, the greatest convexity near or a little posterior to the middle, the surface curving a little more abruptly to the posterior than to the lateral and anterior margins; mesial portion of the valve depressed in a narrow and shallow sinus in the umbonal region which merges anteriorly into a rather broad, ill-defined, flattened band, scarcely or not at all depressed below the general surface, and continuing to the front margin; beak obtuse and only slightly incurved, the umbonal region scarcely protuberant beyond the cardinal margin posteriorly. Surface of the valve apparently smooth or marked only by obscure concentric lines of growth.

Remarks.—This little shell has sometimes been incorrectly identified as *N. barrisi*, but besides occurring in a very different horizon than that species, it is a much smaller shell. The largest example of the species observed by the writer is under 7 mm. in width, and in this specimen the width has been increased by distortion.

Horizon.—Louisiana limestone.

Nucleospira barrisi White

Plate LXXXII, Figs. 27-38

1860. *Nucleospira barrisi* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 227.

1901. *Nucleospira barrisi* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 199, pl. 20, figs. 7-11.

Description.—Shell small, wider than long, the greatest width near the mid-length, transversely subelliptical in outline, the hinge-line very short, the cardinal extremities rounded. The dimensions of a complete pedicle valve, one of the co-types, are: length 9 mm., greatest width 10.6 mm., convexity 2.2 mm. The dimensions of a brachial valve, also one of the co-types, are: length 8.7 mm., greatest width 11.2 mm., convexity 3.1 mm.

Pedicle valve moderately convex, the greatest convexity near or posterior to the middle, the surface sloping with a gently convex curvature to the lateral and anterior margins and curving somewhat more abruptly to the cardinal margin on either side of the beak; mesial sinus originating in the posterior half of the valve, sometimes nearly at the beak, narrow and shallow but often becoming deeper and broader near the front margin and a little produced in a short, rounded extension; beak small, only a little produced beyond the cardinal margin and only moderately incurved; cardinal area wanting, the delthyrium rather large, nearly filled by the beak of the opposite valve, the pseudodeltidium inconspicuous, deeply concave and limited to the apical portion of the delthyrium. Internally the diductor muscular scars are large and flabellate, but are scarcely differentiated at their margins, the adductor scars are much smaller and in mature shells form a narrow, elongate depression in the inner surface of the valve; a low, narrow, mesial septum originates near the apical portion of the valve, in the midst of the adductor scar, and continues nearly to the front margin.

Brachial valve subequally or a little more convex than the pedicle, the greatest convexity near the middle, the surface curving more abruptly to the cardinal margin and gently to the lateral and antero-lateral margins; the mesial fold originating near the middle of the valve, appearing broader than the sinus of the pedicle valve, somewhat abruptly elevated in front in mature shells to accommodate the anterior mesial extension of the pedicle valve, sometimes with a very slight, line-like, mesial depression for a short distance back from the anterior margin in full grown examples. Internally the cardinal process is prominent, and is curved over the margin of the valve and projects posteriorly beyond the margin, nearly filling the umbonal cavity of the pedicle valve when the two valves are in articulation, the surface of the process directed towards the umbonal region of the opposite valve bears a pit-like excavation and its pos-

terior margin is rounded; the muscular scars are more or less ill-defined; a low, narrow, mesial septum similar to that of the pedicle valve originates a little in front of the base of the cardinal process and continues to the middle or beyond the middle of the valve.

Surface of both valves marked only by concentric lines of growth which are commonly restricted to the anterior half of the shell and often occur only close to the anterior margin. The delicate surface spines of the genus have not been observed in any of the specimens studied, possibly because of the condition of preservation.

Remarks.—This species is characterized by the development of a stronger mesial fold and sinus near the front of the shell than is usual in members of the genus. This character, with the not infrequent development of rather strong concentric lines of growth towards the front, suggests a small species of *Athyris,* but the internal characters, the cardinal process of the brachial valve, and the low, elongate, median septum in each valve show at once that its relationships are with the genus *Nucleospira.* The species is also much the largest one which has been recognized in any of our Mississippian faunas. The little shell from the Louisiana limestone which has sometimes been identified as *N. barrisi* is an entirely distinct species and is described in this report as *N. rowleyi.*

Horizon.—Upper Kinderhook.

Nucleospira minima Weller

Plate LXXXII, Figs. 49-60

1906. *Nucleospira minima* Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 447, pl. 6, figs. 29-30.

Description.—Shell very small, subcircular in outline, lenticular, the two valves subequally convex. The dimensions of a large pedicle valve are: length 5 mm., width 6.1 mm., convexity 1.6 mm.

Pedicle valve with its greatest convexity posterior to the middle, the surface curving more abruptly to the cardinal margin and gently to the lateral and anterior margins, not compressed towards the cardinal extremities; the beak short and obtuse, incurved, projecting but slightly beyond the cardinal margin; mesial sinus originating at the beak, narrow and groove-like; internally a faint median septum is present in the rostral portion of the shell and extends anteriorly to about the middle of the valve.

Brachial valve similar to the pedicle, its greatest depth posterior to the middle, the surface not compressed towards the cardinal extremities; the mesial portion of the valve narrowly flattened on the umbo and sometimes slightly depressed as a narrow median sinus anteriorly. Internally a low and narrow median septum continues from the beak nearly to the anterior margin.

Surface of both valves marked by fine, concentric lines of growth.

Remarks.—This species is much smaller than *N. barrisi* and does not possess the rather deep mesial sinus which is commonly developed towards the anterior margin in that species. It is larger and more nearly circular than *N. rowleyi*.

Horizon.—Glen Park limestone of the Kinderhook.

Nucleospira obesa Rowley

Plate LXXXII, Figs. 39-42

1900. *Nucleospira obesa* Rowley, Am. Geol., vol. 25, p. 263, pl. 5, figs. 38-40.

Description.—Shell small, lenticular, subcircular in outline, usually slightly longer than wide, the anterior margin slightly truncated, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of a very perfect specimen, a metatype, are: length of pedicle valve 6.3 mm., length of brachial valve 5.9 mm., greatest width 6 mm., thickness 4 mm., length of hinge-line 2.6 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin on each side of the beak, curving more gently to the lateral and anterior margins; mesial sinus obscure, originating at or near the beak as a slight flattening of the valve, becoming slightly depressed in the umbonal region and continuing to the anterior margin as a narrow and shallow depression with very gradual increase in width and nowhere sharply defined; beak short and small, sharply pointed and moderately incurved; cardinal area small, concave, sloping posteriorly at an angle of about 45 degrees to the plane of the valve, the lateral margins well defined. Internal characters not observed.

Brachial valve nearly equally convex with the pedicle, the greatest convexity posterior to the middle, the surface curving somewhat more abruptly to the posterior than to the lateral and anterior margins, the umbonal region rather prominent and slightly flattened along the median line; near the middle of the valve a slight median sinus originates and continues to the front margin, this sinus being even fainter than that of the opposite valve; the beak rather strongly incurved beneath the delthyrium of the opposite valve. Internal characters not observed.

Surface of both valves, in the specimens observed, nearly smooth, marked only by obscure concentric lines of growth.

Remarks.—The fine appressed surface spines which are commonly present on members of this genus have not been observed in this species, probably because of the condition of preservation. The species differs from *N. barrisi* in its smaller size, more nearly circular shell, and in the absence

of the mesial fold of the brachial valve. It differs from *N. rowleyi* in its larger size, its thicker and more elongate shell.

Horizon.—Lower Burlington white chert.

Genus *CAMAROPHORELLA* Hall and Clarke

Description.—Shells small or of medium size, subcircular, subovate or transversely subelliptical in outline, the valves subequally convex, a fold and sinus present or absent but never strongly developed. Surface of the shell nearly smooth, marked only by fine concentric lines of growth and sometimes by very obscure radiating striæ. The pedicle valve with the beak moderately incurved, perforated by a rather large, subcircular foramen which encroaches upon the umbo, the delthyrium closed by deltidial plates. Internally the dental plates are well developed, they unite before reaching the floor of the valve to form a spondylium which is supported by a median septum which is as long or longer than the spondylium and reaches to about the middle of the valve. In the brachial valve there is a strong median septum extending one-half the length of the valve, which supports the hinge-plate posteriorly; throughout the length of this septum there is a transverse platform which originates beneath the hinge-plate, and which is penetrated by and attached to the septum, at its lateral margins this platform curves towards the floor of the valve and is attached to it, forming a cavity between it and the inner surface of the valve which is divided longitudinally by the median septum, to this platform the adductor muscles were attached. The hinge-plate is deeply concave; the long and slightly curved crura are continuations of this plate, being inserted on its sides near the anterior margin; the spiral cones consist of eight or ten volutions each, the primary lamellæ being united posterior to the middle of the jugum, which rests upon the high median septum, it is saddle-shaped, somewhat similar to the condition in *Athyris,* but much smaller, the accessory lamellæ are placed at a sharp angle to each other, the outer portions lying just without and parallel to the primary lamellæ, they recurve and are attached to the jugum near its base.

Remarks.—This genus was originally described by Hall and Clarke[1] as a near ally of *Camarophoria* because of the well-defined spondylium in the pedicle valve supported by a median septum, associated with the median septum in the brachial valve. It has been shown by Hyde,[2] however, that these shells are spire-bearing with a brachidium of atheroid type. The platform developed in the brachial valve for muscular attachment simulates the cruralium in the same valve in *Camarophoria,* but the lateral margins of the platform curve in the opposite direction from the

[1] Pal. N. Y., vol. 8, pt. 2, p. 215. (1894.)
[2] Proc. Boston Soc. Nat. Hist., vol. 34, No. 3, pp. 35-65 (1908).

margins of the *Camarophoria* cruralium, and become attached to the inner surface of the valve, so forming the pair of slender finger-like cavities lying on either side of the median septum. In addition to the presence of a spondylium in the pedicle valve, the support of the jugum by the high median septum of the brachial valve is a character which has not heretofore been recognized in the atheroid shells. The presence of a spiral brachidium has never been observed in the Kinderhook species here recorded, but in *C. lenticularis* the characters of the septa observed in the internal casts are so entirely like those of the Ohio shells in which the spires have been observed, that their reference to the same genus seems to be well founded.

Camarophorella lenticularis (White and Whitfield)

Plate LXXXII, Figs. 61-63

1862. *Pentamerus lenticularis* White and Whitfield, Proc. Boston Soc. Nat. Hist., vol. 8, p. 295.
1865. *Pantamerus lenticularis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 117.
1894. *Camarophorella lenticularis* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 45, figs. 5-6.
1895. *Camarophorella lenticularis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 62, figs. 46-48.
1901. *Camarophorella lenticularis* Weller, Trans St. Louis Acad. Sci., vol. 11, p. 162, pl. 14, figs. 11-13.
1908. *Camarophorella lenticularis* Hyde, Proc. Boston Soc. Nat. Hist., vol. 34, p. 57, pl. 8, fig. 34.

Description.—Shell small, lenticular, broadly ovate, or subcircular in outline, the width usually greater than the length, the greatest width near the mid-length of the shell. The dimensions of the internal cast of a pedicle valve are: length 11.2 mm., width 13 mm., convexity 3.5 mm.

Ventral valve moderately convex, the greatest convexity posterior to the middle, the surface curving gently from the point of greatest convexity to the lateral and anterior margins, and somewhat more abruptly to the cardinal margin; sinus obsolete or rarely very faintly developed near the anterior margin; the beak pointed, scarcely incurved, projecting beyond that of the opposite valve; internally a strong median septum is developed which reaches nearly half way from the beak to the anterior margin, and supported by the septum is a well-developed spondylium; near the hinge-line a small, horizontal plate is developed from each side, connecting the outer surface of that structure with the inner surface of the valve, on each side of the median septum on the internal casts, the surface is marked by radiating vascular sinuses which do not reach the anterior margin of the valve.

Brachial valve equally or a little less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving gently

from the point of greatest convexity to the lateral and anterior margins and more abruptly to the cardinal margin; mesial fold obsolete; the beak only moderately incurved beneath that of the opposite valve, but not extending as far posteriorly; internally the valve bears a median septum which reaches from the beak anteriorly to or a little beyond the middle of the valve, from each side of this septum, at approximately one-half its height, a horizontal plate is developed whose distal margins for a distance of one-third or less the length of the median septum, rests against the inner surface of the valve, the two plates together forming an elevated platform for muscular attachment, which is excavated beneath, the excavation being divided longitudinally by the median septum. In the internal casts of the valve, as they usually occur, the two finger-like casts of this excavation are usually broken off; on each side of the median septum the surface of the internal casts of the brachial valve is often marked by radiating vascular sinuses similar to those of the opposite valve and not reaching the anterior margin of the shell.

The surface markings of the shell are unknown, but the shell was probably smooth or marked only by concentric lines of growth.

Remarks.—This species is known only in the form of internal casts from the higher, yellow sandstone of the Kinderhook at Burlington, Iowa, and is usually in the condition of casts of separate valves. When the species was made the type of the genus *Camarophorella* by Hall and Clarke, the shell was supposed to be one of the Pentameridæ, but specimens of a closely related species from the Waverly at Sciotoville, Ohio, have recently been shown by Hyde[1] to be spire-bearing, and to belong among the meristelloid forms. No indication of spiral appendages have been detected in the Burlington specimens, but in light of the evidence furnished by the Sciotoville specimens there can be no doubt but that such appendages were present in the living shells. This Kinderhook species differs from the Sciotoville form, *C. mutabilis* Hyde, in its smaller size and in the absence of a median fold and sinus.

Horizon.—Kinderhook.

Camarophorella missouriensis (Winchell)

Plate LXXXII, Figs. 70-79

1865. *Spirigera Missouriensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 117.
1908. *Seminula buckleyi* Rowley, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 79, pl. 17, figs. 48-53.

Description.—Shell below medium size, longer than wide or wider than long, subovate to subpentagonal in outline. The dimensions of the holotype are: length of pedicle valve 16.9 mm., length of brachial valve 14.8

[1] Proc. Boston Soc. Nat. Hist., vol. 34, pp. 35-65 (1908).

mm., greatest width 16 mm., thickness 10.4 mm. The dimensions of a metatype of *Seminula buckleyi* are: length of pedicle valve 15 mm., length of brachial valve 13.5 mm., greatest width 15.6 mm., thickness 7.9 mm.

Pedicle valve deepest posterior to the middle, the umbo rather prominent, the surface curving abruptly from the umbonal region to the postero-lateral margins becoming distinctly inflected to the cardinal extremities, passing with a more gently convex curvature to the antero-lateral and anterior margins; mesial sinus originating at the beak where it is narrow and shallow, growing distinctly broader and deeper towards the front, rounded in the bottom, its sides curving regularly into the lateral slopes of the valve; the beak prominent and rather strongly incurved, perforated by a foramen of moderate size which encroaches upon the umbonal region, the delthyrium closed by a pseudodeltidium above and by the beak of the opposite valve below. Internally a strong median septum extends anteriorly from the beak for nearly one-half the length of the valve, the dental lamellæ not clearly distinguished in any specimen observed but probably joined to form a spondylium supported by the median septum.

Brachial valve about equally convex with the pedicle, its greatest depth posterior to the middle, the surface sloping with a gently convex curvature to the antero-lateral and anterior margins, curving somewhat more abruptly to the postero-lateral margins, the beak strongly incurved and passing beneath the margin of the pseudodeltidium of the opposite valve: a narrow, shallow, rounded, median sinus similar to, but somewhat smaller than that of the opposite valve, originates at the beak and passes to about the middle of the mature valve, where it gradually becomes obsolete, mesial fold obsolete or slightly developed near the front margin in mature shells where it is scarcely differentiated from the general curvature of the surface. Internally a strong median septum is present, extending from the beak to about the middle of the valve, the remaining internal features not observed.

Surface of both valves marked by concentric lines of growth which are variable in strength and distribution.

Remarks.—Only three examples of this rare species have come under the observation of the writer, the largest being Winchell's holotype of the species. The other two examples are from the collection of Prof. R. R. Rowley, a cotype and a metatype of his *Seminula buckleyi*. The internal features of the shell, so far as they are known, are shown only in the larger of the two specimens from the Rowley collection. This specimen is exfoliated sufficiently to clearly show the strong median septum in each valve as a dark line passing anteriorly from the beak. The presence of these median septa exclude the species from the group of athyroid shells where it has usually been thought to belong, but without further knowl-

edge of the internal characters, which in this case can only be gained by sectioning the specimens, the true relationships of the species cannot be certainly determined. So far as can be determined, considering both the external form and the internal structures, the species seems to be most closely allied to the meristoid genus *Camarophorella*, where it is here placed, but further knowledge of the shells may show that the species should be considered as the type of a new genus. The external feature of the shell which seems to be especially characteristic, is the presence of a faint median sinus of the brachial valve which does not continue to the front margin in mature examples. The general outline of the shell seems to be rather variable, judging from the three examples studied. Of the previously known species of *Camarophorella* this species most closely resembles *C. mutabilis* Hyde.[1] The general contour of the two species is essentially the same, including the faint median sinus in the posterior portion of the brachial valve, but *C. missouriensis* differs from *C. mutabilis* in the entire absence of the faint radiating striæ of that species.

Horizon.—Louisiana limestone.

Genus *ROWLEYELLA* Weller

Description.—Shells small, subovate in outline, with subequally convex valves, fold and sinus wanting, the surface of the shell marked only by inconspicuous concentric lines of growth. Pedicle valve with the beak moderately incurved and perforated at its apex by a subcircular foramen which encroaches wholly upon the umbonal region, in contact with the delthyrium only at its apex, the delthyrium closed by deltidial plates. Internally a strong median septum is present which reaches about one-third the length of the valve, it supports a spondylium formed by the union of the dental plates. In the brachial valve is a strong median septum which reaches anteriorly for one-third or more of the length of the valve, its connection with the hinge-plate and brachidium has not been determined and if a platform beneath the hinge-plate, such as occurs in *Camarophorella* is present, its outer margins do not join the inner surface of the valve to form the pair of finger-like cavities which are present in that genus; the attachment of the brachidium to the crura and the form of the jugum unknown, the spiral cones are directed laterally and consist of about four volutions.

Remarks.—The terebratuliform contour of the shell of the single member of this genus, strongly suggests its being a loop-bearing brachiopod, and the genotype was originally described as a *Terebratula*. At the time the generic name *Rowleyella* was proposed for this species the presence of a spiral brachidium had not been detected, and while it was recognized that the presence of a median septum in the pedicle valve was an un-

[1] Proc. Boston Soc. Nat. Hist., vol. 34, No. 3, p. 56 (1908).

known character among the terebratuloid shells, it was placed among them tentatively. When the specimens were set up for photographing, on bits of modeling clay, and allowed to remain for several days, the oil from the clay was absorbed by the specimens in such a manner as to bring out clearly the presence of a perfectly preserved spiral brachidium in one of the specimens. The relationships of the genus are clearly with *Camarophorella,* the only important differential character which can be pointed out, with our present knowledge, being the absence of the platform for muscular attachment in the brachial valve with its margins recurved to the inner surface of the valve to enclose the two finger-like cavities. If a platform of this sort is present, its margins are entirely free. The attachment of the jugum to the median septum of the brachial valve is another important character of *Camarophorella,* but it is impossible to determine either the presence or the absence of such an attachment in the specimens of *Rowleyella* which are available for study.

Rowleyella fabulites (Rowley)

Plate LXXXII, Figs. 64-69

1900. *Terebratula fabulites* Rowley, Am. Geol., vol. 25, p. 265, pl. 5, figs. 51-53.
1911. *Rowleyella fabulites* Weller, Jour. Geol., vol. 19, p. 448.

Description.—Shell small, terebratuliform, subovate in outline, the greatest width near or in front of the mid-length, the anterior margin rounded. The dimensions of a nearly complete example, but with most of the pedicle valve exfoliated, are: length of pedicle valve 6 mm., length of brachial valve 5.8 mm., greatest width 5 mm., thickness 3.6 mm.

Pedicle valve convex, with the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the postero-lateral margins and slightly inflected to the cardinal extremities, curving more gently to the antero-lateral and anterior margins, anteriorly from near the middle of the valve the surface is slightly flattened in its median portion, but is not at all depressed in a mesial sinus; the beak is of moderate size, incurved; the foramen of moderate size, subcircular in outline and wholly encroaching upon the umbonal portion of the valve; the delthyrium not entirely hidden by the incurvature of the beak and apparently closed by a pseudodeltidium. Internally the dental plates are well developed and become joined before reaching the floor of the valve to form a distinct spondylium supported by a strong median septum which reaches anteriorly nearly to the center of the valve.

Brachial valve a little less convex than the pedicle, the surface curving somewhat more abruptly to the posterior and postero-lateral than to the anterior and antero-lateral margins; mesial portion scarcely or not at all differentiated from the general curvature of the valve; the beak incurved

beneath the covering of the delthyrium of the opposite valve. Internally a strong median septum extends anteriorly from the beak for about one-third the length of the valve.

Surface of both valves marked by moderately strong, somewhat irregularly distributed, concentric lines of growth.

Remarks.—In the original definition it is stated that only two examples of this shell had been found by the author of the species. These two original examples, with two additional ones in the collection of Walker Museum, are all that have come under the observation of the writer. Of Rowley's two co-types, one, the figured one, has the shell entirely preserved, but the second example is partially exfoliated and distinctly shows the median septum of the brachial valve. Of the two Walker Museum specimens, the larger and more complete one, whose dimensions are given above, and which has served mainly as the basis of the above description, is partially exfoliated so that the median septum of the pedicle valve is clearly exhibited, and the smaller is an internal cast throughout, so that the mesial septa of both valves are clearly seen. Rowley's figured type has been carefully examined, and although the shell itself is intact, the presence of a median septum in each valve seems to be clearly indicated. The specimen here illustrated is somewhat broader, proportionally, than the figured type.

Horizon.—Lower Burlington limestone (white chert).

Family ATHYRIDÆ

Genus *ATHYRIS* McCoy

Description.—Shells usually of medium size or larger, transversely subelliptical, subcircular or subovate in outline, the valves subequally convex, the median sinus of the pedicle valve and the fold of brachial valve usually limited to the anterior portion of the shell and sometimes obsolete. In the pedicle valve the beak is usually incurved so as to conceal the foramen and delthyrium, deltidial plates usually absent. Internally the hinge-teeth are prominent, recurved at the tips, and are supported by short but rather stout dental lamellæ which are not produced anteriorly about the muscular area; between the dental lamellæ is a deep, transversely striated pedicle cavity, and in front of this an ovate muscular area extending about one-half the length of the valve; the diductor scars are flabellate and usually ill-defined about the margins, and the adductors occupy a narrow central area more sharply defined. In the brachial valve the dental sockets are broad and deep, the socket walls are connected by a hinge-plate which is perforated posteriorly, close to the beak of the valve, by a circular opening, the median portion of the plate is flat or concave, the lateral margins are thickened and are produced anteriorly into

the crura. The spiral cones of the brachidium lie base to base with the apices directed laterally, the crura are long and convergent with the primary lamellæ, abruptly recurving at their points of origin, the jugum is saddle shaped in its main portion and is situated posterior to the middle of the shell, the anterior extremity of the saddle may be simple or divided, posteriorly it is narrowed and inclined towards the beak of the valve for a short distance, thence rises abruptly towards the umbo of the pedicle valve, bifurcates near the extremities of the crura, each branch following the curvature of the primary lamella, so forming accessory lamellæ which lie between the primary lamellæ and the first band of the secondary lamellæ. The surface of the valves is marked by broad, lamellar expansions of the shell at each growth line.

Remarks.—All the atheroid shells are characterized by a hinge-plate with an apical perforation, and in the internal casts of the shells, the filling of the cavity beneath the hinge-plate, running up as a finger-like point to the perforation and directed towards the beak of the opposite valve, is a very conspicuous feature of the brachial valve. The several generic groups of these species are differentiated largely by the general outline of the shell, and especially by the nature of the surface markings. In *Athyris* proper the lamellar extensions of the shell are highly characteristic.

ATHYRIS LAMELLOSA (Léveillé)

Plate LXXVIII, Figs. 1-5; 15-20

1835. *Spirifer lamellosus* Léveillé, Mem. Soc. Geol. de France, 1st ser., vol. 2, p. 39, figs. 21-23.
1875. *Athyris lamellosa ?* Meek, Pal. Ohio, vol. 2, p. 283, pl. 14, figs 6a-b.
1888. *Athyris lamellosa* Herrick, Bull. Sci. Lab. Denison Univ., vol. 3, p. 49, pl. 2, fig. 7.
1888. *Athyris ashlandensis* Herrick, Bull. Sci. Lab. Denison Univ., vol. 4, p. 24, pl. 3, fig. 6.
1894. *Athyris incrassatus* Keyes, Mo. Geol. Surv., vol. 5, p. 91, pl. 41, fig. 10.
1895. *Athyris ashlandensis* Herrick, Geol. Surv. Ohio, vol. 7, pl. 23, fig. 10.
1895. *Athyris lamellosa* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, figs. 16-20.
1899. *Athyris lamellosa* Weller, Trans. St. Louis Acad. Sci., vol. 9, p. 21, pl. 4, fig. 8.
1899. *Athyris lamellosa* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 561, pl. 71, fig. 7a.
1904. *Athyris lamellosa* Girty, Prof. Paper U. S. Geol. Survey, No. 21, p. 49, pl. 10, figs. 12-13.
1909. *Athyris lamellosa* Weller, Bull. Geol. Soc. Am., vol. 20, p. 312, pl. 14, figs. 5-6.

Description.—Shell of medium size or larger, transversely subelliptical in outline, the valves moderately convex, the length two-thirds or more than two-thirds the width, the greatest width near or a little posterior to the mid-length of the shell, the hinge-line much shorter than the greatest width of the shell, cardinal extremities rounded. The dimensions of a rather large individual are: length 39 mm., width 51 mm., approximate thickness ±24 mm.

Pedicle valve moderately convex, the greatest convexity near or posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin and gently to the lateral and anterior margins, frequently somewhat compressed towards the cardinal extremities; the beak contiguous with that of the opposite valve, pierced by a subcircular foramen; cardinal area very narrow and inconspicuous, the lateral margins usually well defined; delthyrium broadly triangular, the width three or four times the height, nearly filled by the cardinal process and hinge-plate of the brachial valve when the two valves are in articulation, the apex connected with the foramen; lateral slopes convex except towards the cardinal extremities where they sometimes become a little concave; mesial sinus originating at or near the beak, shallow, rounded in the bottom, rather narrow and more or less illdefined laterally, often curving rather abruptly towards the opposite valve in adult specimens as it approaches the anterior margin.

Brachial valve equally or a little more convex than the pedicle, the greatest convexity posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the antero-lateral margins, sometimes a little compressed towards the cardinal extremities; the beak rather strongly incurved beneath that of the opposite valve; mesial fold low, rounded and ill-defined laterally, sometimes becoming obsolete towards the beak, often rather abruptly elevated in front in adult individuals.

Surface of both valves marked by strong, subparallel, concentric, lamelliform extensions 3 to 5 mm. apart, towards the front of the shell they are often much more closely crowded, and on the body of the shell weaker lamellæ are often intercalated between the stronger ones. In all cases where the surface is well preserved, subparallel lines of greater or less strength are disposed irregularly between the stonger lamellæ.

Remarks.—This species occurs not infrequently in such condition of preservation that the surface characters are more or less obscure, but in all cases, even in internal casts, the concentric lamellæ are indicated by the presence of ridges. In internal casts which are frequently found in the cherts of the Osage formations, the subovate muscular scar of the pedicle valve is more or less strongly defined, dependent upon the age of the individual, the length of the muscular scar is about equal to the dis-

tance from its anterior margin to the anterior margin of the shell, posteriorly from the muscular scar, the cast of the transversely striated pedicle cavity is sharply differentiated, its length being about one-half that of the muscular scar; the dental lamellæ, represented by narrow slits in the cast, extend forward to the anterior margin of the pedicle cavity. In the casts of the brachial valves the cast of the passageway through the posterior margin of the hinge-plate to the cavity of the shell is a conspicuous feature, being represented as a median, finger-like process extending towards the beak of the opposite valve in a direction nearly at right angles to the plane between the two valves.

The species is a common and only moderately variable one. The different appearance of the concentric markings of the shell is frequently due to differences in condition of preservation, but they also vary to some extent in their distance apart. Different examples exhibit some variation in the proportional length and width, but they are frequently crushed so as to make accurate measurement impracticable.

Horizon.—Upper Kinderhook, Burlington limestone and Keokuk limestone.

ATHYRIS HANNIBALENSIS (Swallow)

Plate LXXVIII, Figs. 10-14

1860. *Spirigera Hannibalensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 649.
1865. *Spirigera Hannibalensis* Winchell, Proc. Acad. Nat. Sci. Phil., p. 118.
1894. *Athyris hannibalensis* Keyes, Mo. Geol. Surv., vol. 5, p. 91, pl. 41, fig. 9.
1895. *Athyris Hannibalensis* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, figs. 13-15.
1908. *Athyris hannibalensis* Rowley, Mo. Bureau Geol. and Mines, vol. 8, ser. 2, p. 86, pl. 18, figs. 28-30.

Description.—Shell of medium size, subelliptical or approaching subcircular in outline, the valves moderately and subequally convex, the length usually about seven-eighths of the width when the lamellar extensions of the shell are removed, the hinge-line less than one-half the width of the shell, the cardinal extremities rounded, the greatest width near the mid-length of the shell. The dimensions of two complete individuals of about average size are: length 21.5 mm. and 21 mm., width 25 mm. and 23.5 mm., thickness 13 mm. and 12.5 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margins, and gently to the lateral and anterior margins; the beak small and contiguous with that of the opposite valve, pierced by a subcircular foramen; cardinal area narrow and inconspicuous, its lateral margins more or less well defined; the delthyrium broadly triangu-

lar, the width three or four times the height, nearly filled with the cardinal processes and the hinge-plate of the opposite valve when the two valves are in articulation, the apex connecting with the foramen which encroaches upon the beak; lateral slopes convex, the convexity continuing to the cardinal extremities except rarely when the valve is slightly compressed in that direction; mesial sinus more or less obscure, rather narrow and ill-defined laterally, occasionally essentially obsolete, sometimes rather deep, usually developed to a moderate degree, originating at or near the beak as a mesial flattening of the valve and becoming more depressed towards the front.

Brachial valve a little more convex than the pedicle, the greatest convexity near or posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the antero-lateral margins; the beak incurved beneath that of the opposite valve; mesial fold obscure, as usually developed it is a mesial flattening of the valve slightly or not at all elevated posteriorly, and but little elevated anteriorly.

Surface of each valve marked by more or less irregular, sub-parallel, concentric, lamelliform extensions from one to three millimeters apart, those towards the front of the shell becoming more crowded. Between these stronger markings much fainter concentric markings may sometimes be detected.

Remarks.—This species is a close ally of *A. lamellosa*, and should perhaps not be considered as distinct from it. There seems to be a constant difference between the two species, however, in the smaller size of *A. hannibalensis* and in its greater proportional length, its outline being much more nearly subcircular. The concentric lamellæ are also usually closer together in this species, a feature which might be expected from its smaller size. The character of the surface markings of the shell are essentially the same in both forms. So far as it has been recognized, this species is restricted in its distribution to the Kinderhook faunas.

Horizon.—Kinderhook.

Athyris papilioniformis McChesney

Plate LXXVIII, Figs. 6-9

1860. *Athyris spiriferoides* McChesney, Desc. New Spec. Pal. Foss., p. 46. (Not *A. spiriferoides* Eaton, 1831.)
1865. *Athyris papilioniformis* McChesney, Ill. New Spec. Foss., pl. 6, figs. 4a-c.
1868. *Athyris ? papilioniformis* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 33, pl. 6, figs. 4a-c.

Description.—Shell of medium size, the valves moderately convex, wider than long, the greatest width near the cardinal margin, the hinge-line nearly equal to the greatest width of the shell, the cardinal extremi-

ties a little rounded. The dimensions of the type specimen are: length 17.5 mm., width 28 mm., length of hinge-line 27 mm., thickness 12.5 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, sloping in nearly straight lines to the cardinal extremities and curving gently to the antero-lateral margins; the beak contiguous with that of the opposite valve, apparently pierced by a subcircular foramen; cardinal area narrow and somewhat ill-defined; the characters of the delthyrium not determinable upon the type specimen, but it is probably broadly triangular as in *A. lamellosa;* lateral slopes of the valve convex; mesial sinus deep and sub-angular in the bottom, originating at the beak, rather sharply defined laterally.

Brachial valve about equally convex with the pedicle, the greatest convexity near the middle, the surface curving gently to the cardinal margin except for a short distance on each side of the beak where it is more abrupt, the curvature to the antero-lateral margins is gentle, and the surface is somewhat compressed towards the cardinal extremities; the beak incurved beneath that of the opposite valve; the mesial fold originating at the beak, flattened on top and becoming somewhat abruptly elevated towards the front of the shell, apparently with a longitudinal, mesial depression anteriorly.

Surface of both valves marked by concentric lamellæ from one to two millimeters apart on the central portion of the shell, becoming more conspicuous and somewhat crowded towards the anterior margin.

Remarks.—The description of this species has been made from a very perfect sulphur cast of the type specimen. The type itself has been lost and no other example of the species has been seen by the writer. It differs from *A. lamellosa* in its smaller size, its greater proportional width with the greatest width near the hinge-line, its much longer hinge-line and its much stronger fold and sinus. The concentric lamellæ of the shell are represented by their basal portions only, but when perfectly preserved they doubtless were produced into lamelliform extensions similar to those on *A. lamellosa,* but much thinner and closer together.

Horizon.—Chester group.

Athyris densa Hall

Plate LXXVII, Figs. 60-69

1882. *Centronella crassicardinalis* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 55, pl. 6, figs. 50-52 (not *Athyris crassicardinalis* White, 1860).
1883. *Centronella crassicardinalis* Hall, 12th Ann. Rep. Geol. Surv. Ind., pl. 29, figs. 50-52.
1894. *Athyris densa* Hall, 13th Rep. N. Y. State Geol., p. 651.
1895. *Athyris densa* Hall and Clarke, Pal N. Y., vol. 8, pt. 2, p. 364, pl. 46, figs. 6-12.

1897. *Athyris densa* Hall, 14th Rep. N. Y. State Geol., p. 358, pl. 9, figs. 3-9.
1906. *Centronella ? ? crassicardinalis* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1308, pl. 22, figs. 50-52.
1906. *Athyris densa* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1320, pl. 19, figs. 2-2c.

Description.—Shell below medium size, wider than long, the valves much thickened posteriorly, unequally convex, the greatest width near the mid-length of the shell, the hinge-line arcuate, shorter than the greatest width, the cardinal extremities rounded. The dimensions of a complete specimen, one of the co-types of the species, are: length 18 mm., width 22 mm., thickness 11.5 mm.

Pedicle valve shallow, depressed in its posterior half, curving towards the opposite valve anteriorly, the surface nearly straight, gently convex or sometimes a little concave along the transverse line of the valve between the points of greatest lateral extent, except near the lateral margins where it is abruptly bent towards the opposite valve and is even inflected in the larger examples; the beak not incurved, contiguous with the umbo of the opposite valve, pierced by a small sub-semicircular foramen which is joined broadly with the apex of the delthyrium; the false cardinal area sharply defined along its ventral margin or curving very abruptly into the lateral slopes of the valve, rather broad and nearly flat, or slightly concave from the cardinal to the ventral margins, the two portions of the area on opposite sides of the delthyrium not lying in a plane, if produced to the center of the delthyrium they would meet in an obtuse angle, laterally the area continues on each side with the curvature of the valve nearly or quite to the greatest transverse diameter of the valve; delthyrium broadly triangular, wider than high, nearly filled by the beak and cardinal processes of the opposite valve when the valves are in articulation, the apex connected with the foramen; lateral slopes depressed, nearly straight transversely, but convex antero-posteriorly; mesial sinus originating near or at some distance anterior to the beak, shallow, usually narrow but sometimes broad and ill-defined, produced anteriorly in adult individuals.

Brachial valve more strongly convex than the pedicle, the greatest convexity near the middle, the surface sloping with a convex curvature from the median line to the lateral margins, the curvature somewhat more abrupt towards the cardinal and anterior margins; the beak incurved beneath that of the opposite valve; mesial fold ill-defined laterally, passing without demarkation into the lateral slopes, flattened on top or sometimes with a median longitudinal depression towards the front.

Surface of both valves marked by fine, sublamellose, concentric lines of growth, which are crowded at intervals, especially towards the front, to form much stronger growth lines.

Remarks.—This species may be easily recognized by the transversely flattened surface of the pedicle valve, and by the conspicuous false cardinal area of the same valve. It was originally described by Whitfield as *Centronella crassicardinalis*, but is clearly not a member of that genus. Whitfield's specific name is preoccupied in the genus *Athyris* by *A. crassicardinalis* White, consequently the name *A. densa* H. and C., must be retained for the species. Whitfield's description was based upon a single, small pedicle valve which was proportionally somewhat more elongate than usual, but is clearly the same as Hall and Clarke's species.

Horizon.—Salem limestone.

ATHYRIS CRASSICARDINALIS White

Plate LXXVII, Figs. 1-20

1860. *Athyris crassicardinalis* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 229.
1899. *Cliothyris crassicardinalis* Girty, Mon. U. S. Geol. Survey, vol. 32, p. 567, pl. 71, fig. 8a.
1901. *Athyris crassicardinalis* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 186, pl. 16, figs. 18-24.

Description.—Shell small, biconvex, suboval or subcircular in outline, the width equal to or greater than the length, the greatest width near the mid-length of the shell, the hinge-line shorter than the greatest width, the cardinal extremities rounded. The dimensions of two pedicle valves are: length 9 mm. and 10.3 mm., width 10 mm. and 10.2 mm., convexity 4.5 mm and 4 mm. The dimensions of a brachial valve are: length 8 mm., width 9 mm., convexity 3 mm.

Pedicle valve strongly convex, the greatest convexity near or posterior to the middle, most elevated along the median line, the surface curving abruptly from the umbonal region towards the cardinal margin and sloping laterally from the median line with a gently convex curvature; median sinus obsolete, the median portion of the valve slightly flattened in an ill-defined, narrow band from which the surface slopes laterally in each direction; beak small, pointed, moderately incurved; cardinal area obsolete; delthyrium large, open, broadly triangular. Internally the hinge-teeth are large and strong, they are nearly horizontal in position and are directed medially, growing out from the inner surface of the valve as shelf-like processes which are concave externally; the muscular scars are large but ill-defined, sometimes divided longitudinally by a slightly raised rib.

Brachial valve much less convex than the pedicle valve, arched from the posterior to the anterior margins, depressed-convex transversely; mesial fold obsolete, the median portion of the valve slightly flattened along a narrow, ill-defined region from which the surface slopes laterally;

beak small, moderately incurved. Internally the cardinal process is very broad and thick, and is coalesced with the socket plates, the hinge sockets being excavated from its sides, its main surface lies nearly parallel to the plane of the valve, is subcrescentic in outline, with a raised margin posteriorly and laterally, anteriorly the surface drops abruptly to the floor of the valve, the lateral margins are extended farther anteriorly than the median part and doubtless bear the crura; the muscular scars smaller and a little more deeply excavated and more sharply defined than those of the opposite valve, divided longitudinally by a faint median septum.

Surface of both valves smooth, or nearly smooth, marked only by more or less indistinct, concentric lines of growth.

Remarks.—The generic relations of this shell are uncertain. It is not a true member of the genus *Athyris,* neither can it be placed in another genus with any more certainty. It is not unlikely a representative of an undescribed genus, but the character of its brachidium should be known before defining it as new. For the present, therefore, it may be allowed to remain in *Athyris,* where it was originally placed by the author of the species.

Horizon.—Upper Kinderhook.

Genus *CLIOTHYRIDINA* Buckman

Description.—Shells small, of medium size or large, from subcircular to transversely subelliptical in outline, mesial sinus of the pedicle valve and fold of the brachial valve well developed or obsolete, the surface of the valves marked by broad, thin, lamellar extensions, which are divided nearly or quite to their bases into long, flat spines. The beak of the pedicle valve usually incurved so as to conceal the foramen and delthyrium in the mature shells, the dental lamellæ and muscular scars as in *Athyris.* In the brachial valve the hinge-plate and brachidium are similar to the same structures in *Athyris.*

Remarks.—This generic group has been called *Cliothyris* by Hall and Clarke,[1] on King's authority, and authors have commonly used that name since the publication of their work. It has been shown by Buckman,[2] however, that the name *Cliothyris* must be accredited to Phillips and if used at all must be considered as a synonym of *Athyris,* over which it has priority, and he has proposed the new generic name *Cliothyridina* to designate this group of shells. The genus differs from *Athyris,* as used in this work, in the form of its surface markings, the concentric lamellæ developed from the lines of growth being divided into flat spines by deep incisions. These fringe-like lamellæ are commonly more or less

[1] Pal. N. Y., vol. 8, pt. 2, p. 90. (1894.)
[2] Ann. and Mag. Nat. Hist., ser. 7, vol. 18, p. 321 (1906).

completely removed from the fossil specimens, but usually some bases of the spines or more complete fragments of the lamellæ can be detected unless the shell has been too badly exfoliated. This is the commoner genus of the two in our faunas, and the shells are usually smaller and more lenticular than *Athyris,* although this statement is not applicable to all the species of the genus.

Cliothyridina glenparkensis n. sp.

Plate LXXVIII, Figs. 21-24

1909. *Cleiothyris royssi* Weller, Bull. Geol. Soc. Am., vol. 20, p. 313, pl. 14, figs. 1-3.

Description.—Shell lenticular in form, the two valves nearly equally convex, transversely subelliptical in outline, the length about six-sevenths of the width, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width. The dimensions of a nearly perfect individual are: length 18 mm., width 21 mm., thickness 9.5 mm.

Pedicle valve moderately convex, the greatest depth posterior to the middle, the surface curving most abruptly to the cardinal margin; the mesial portion of the valve slightly flattened, and sometimes slightly depressed anteriorly in a narrow, obscure sinus; the beak small, pointed, in close contact with the umbo of the opposite valve, pierced by a subcircular foramen; cardinal area obsolete, the delthyrium broadly triangular and filled by the beak of the opposite valve.

Brachial valve subequally or sometimes slightly more convex than the pedicle, the greatest depth near or a little posterior to the middle, the surface slightly compressed towards the cardinal extremities; the mesial portion of the valve flattened along a narrow band from the beak to the front margin, but not elevated into a fold, the mesial flattening of the valve being more conspicuous than that of the opposite valve; the beak incurved beneath that of the opposite valve and filling the delthyrium.

Surface of both valves marked by regular, fine, crowded, concentric, imbricating, lamellose lines of growth, which, when the surface characters are perfectly preserved are produced into rows of closely imbricating fringes of flattened spines.

Remarks.—The species *Athyris roissyi* has been given so broad an interpretation by Davidson,[1] as to include essentially all of the species here referred to the genus *Cliothyridina,* but as used by DeKoninck, the name applies to shells which are essentially like those here described as *C. glenparkensis;* Léveillé's original illustrations of the species, however, represent a shell with a well-developed fold and sinus similar to the American *C.*

[1] Brit. Foss. Brach., vol. 2, p. 84, pl. 18, figs. 1-11. (1860.)

prouti, so the name cannot be used to designate the shell under consideration. *C. glenparkensis* is perhaps most closely related to *C. hirsuta,* but it is larger than that species and is proportionally broader and thinner, with more crowded and thinner pectinated lamellæ. It differs from *C. sublamellosa,* which has sometimes been referred to *C. roissyi* in being broader and thinner, and in having the valves subequally convex. In size the species exhibits considerable variation, some examples attaining a length of 30 mm. or more, but none of these larger individuals have been observed in an undistorted condition.

Horizon.—Fern Glen formation.

Cleiothyridina prouti (Swallow)

Plate LXXIX, Figs. 13-16

1860. *Spirigera Proutii* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 649.
1881. *Spirifera temeraria* Miller, Jour. Cinn. Soc. Nat. Hist., vol. 4, p. 314, pl. 7, figs. 9-9b.
1894. *Athyris proutii* Keyes, Mo. Geol. Surv., vol. 5, p. 91.
1909. *Cleiothyris prouti* Weller, Bull. Geol. Soc. Am., vol. 20, p. 314, pl. 14, figs. 12-15.

Description.—Shell transversely subelliptical in outline, the greatest width near the mid-length of the shell, the hinge-line shorter than the greatest width, the cardinal extremities rounded, the fold and sinus conspicuously developed. The dimensions of two individuals are: length 17.5 mm. and 16 mm., width 22.5 mm. and 21.5 mm., thickness 15 mm. and 11 mm.

Pedicle valve strongly convex, most prominent posterior to the middle, the surface curving strongly from the umbonal region to the margins, most abruptly to the cardinal margin; mesial sinus large and deep, originating near the beak and becoming proportionally more profound anteriorly, rounded in the bottom, defined on each side by a rounded ridge, in mature individuals produced anteriorly into a lingual extension of greater or less length; beak rather prominent, incurved, in close contact with the umbo of the opposite valve, pierced by a circular foramen; cardinal area obsolete except in old shells in which there is a more or less conspicuous, flattened border or false cardinal area along the cardinal margin; delthyrium broadly triangular, nearly filled by the beak of the opposite valve.

Brachial valve strongly convex, the greatest convexity near or anterior to the middle, the surface rather strongly convex from the cardinal to the anterior margin; mesial fold obscure or obsolete posteriorly, becoming strongly developed anteriorly, especially in old shells, more or less ill-defined laterally; the beak strongly incurved, nearly filling the delthyrium of the opposite valve.

Surface of both valves marked by closely arranged, thin, concentric, imbricating lamellæ, which are produced very regularly into fine, flattened spines, the spines of successive concentric rows being arranged in radiating series so that the entire surface, even when the spines themselves are in large part destroyed, presents the appearance of being regularly and finely marked in a reticulate manner.

Remarks.—This species is not closely allied to any other American member of the genus. Its nearest allies are found in the European *Athyris squamigera* DeKon. and *Athyris roissyi* Léveillé.

Horizon.—Chouteau limestone and Fern Glen formation.

Cliothyridina obmaxima (McChesney)

Plate LXXIX, Figs. 1-11

1861. *Athyris obmaxima* McChesney, Desc. New Spec. Foss., p. 80.
1863. *Spirigera pectinifera* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 88.
1874. *Spirigera obmaxima* White, Prelim. Rep. Inv. Foss., p. 17.
1877. *Spirigera obmaxima* White, U. S. Geol. Surveys W. 100th Mer., vol. 4, p. 92, pl. 5, fig. 12.
1895. *Athyris incrassata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 83, fig. 39. (Not pl. 46, fig. 21.)
1909. *Cleiothyris incrassata* Weller, Bull. Geol. Soc. Am., vol. 20, p. 313, pl. 14, figs. 8-10.

Description.—Shell large, transversely subelliptical in outline, greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded, fold and sinus strongly developed towards the anterior margin. The dimensions of a nearly perfect individual are: length 40 mm., width 52 mm., thickness 24 mm. Some of the largest examples have a width of 75 mm. or more.

Pedicle valve rather strongly convex, strongly arched from beak to front along the median line, the greatest prominence posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, and much more gently to the antero-lateral margins, sometimes a little compressed towards the cardinal extremities; mesial sinus obscure or obsolete at the beak, but usually originating in or near the umbonal region, rounded in the bottom and ill-defined laterally, growing rapidly stronger anteriorly, often becoming profound near the anterior margin and produced in a lingual extension of greater or less length; beak rather small and pointed, incurved, in contact with the umbonal region of the opposite valve, pierced by a subcircular, oblique foramen; cardinal area obsolete, the delthyrium broadly triangular, connected at its apex with the foramen, almost entirely filled with the beak of the opposite valve.

Brachial valve somewhat more convex than the pedicle, the greatest convexity towards the anterior margin, the surface strongly convex on each side of the fold and sinus, the curvature being most abrupt to the cardinal margin and least to the lateral margins; mesial fold obscure or obsolete towards the beak, becoming strongly elevated anteriorly, rounded on top and not sharply defined laterally; beak strongly incurved and filling the delthyrium of the opposite valve.

Surface of both valves, as usually preserved and when not greatly exfoliated, marked by crowded, more or less regular, thin, imbricating lamellose lines of growth, which are often somewhat wavy along their free margins. In rare instances the concentric lamellæ are seen to be produced into thin, rather broad, lamellæ, which are divided by grooves or slits into ribs or spines, giving to the shell the essential characteristics of the genus *Cliothyridina*.

Remarks.—This species has commonly been confused with *C. incrassata*. The two forms are closely allied, but they seem to be sufficiently distinct to warrant their recognition as separate species, although it is probable that some intermediate examples may be found. *C. obmaxima* grows to a larger size than *C. incrassata*, sometimes attaining a width of 75 mm. or more; it is always broader than long, with a profound sinus which originates nearer the beak than that of *C. incrassata*. The species occurs most commonly in the Fern Glen formation and in the Keokuk, while *C. incrassata* has been observed only in the Burlington limestone. The shell described as *Spirigera pectinifera* by Swallow, has never been illustrated, and the types are lost, but the description is a good one and closely applies to an example of *C. obmaxima*, upon which some of the delicate surface markings are preserved, the species is recorded from Keokuk, Iowa, from which locality many excellent examples of *C. obmaxima* have been secured.

Among European species the shell described by Phillips as *Spirifera glabristria*,[1] is perhaps identical with our American *C. obmaxima*. Davidson has included the form in his broad interpretation of *Athyris roissyi*,[2] and DeKoninck has described a new species under the name *Athyris ingens*,[3] which is a close ally. Phillips' specific name has priority, and if the American shell should be considered as identical with the European, the name *C. glabristria* Phill., would have to take precedence over *C. obmaxima* McChesney.

Horizon.—Upper Kinderhook, Burlington limestone and Keokuk limestone.

1 Geol. Yorks., vol. 2, p. 220, pl. 10, fig. 19 (1836).
2 Brit. Foss. Brach., vol. 2, p. 84, pl. 18, figs. 1-4 (1860).
3 Faun. du Calc. Carb. de la Belg., pt. 6, p. 85, pl. 20, figs. 1-10. (1887.)

Cliothyridina incrassata (Hall)

Plate LXXIX, Fig. 12

1858. *Athyris incrassatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 600, pl. 12, fig. 6.
1895. *Athyris incrassata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, fig. 21. (Not pl. 83, fig. 39.)
1899. *Athyris incrassata* (?) Girty, Mon. U. S. Geol. Survey, vol. 32, p. 562.

Description.—Shell above medium size, subovate in outline, the length and width subequal, or longer than wide, the greatest width near the mid-length; the hinge-line much shorter than the greatest width, the cardinal extremities rounded; fold and sinus strongly developed anteriorly. The dimensions of a nearly complete pedicle valve are: length ±42.5 mm., width 40 mm., convexity 10 mm. The dimensions of a brachial valve are: length 40 mm., width 45 mm., convexity 15 mm.

Pedicle valve moderately convex, arched from the beak to the front margin along the median line, greatest depth near the middle, the surface curving rather abruptly from the umbonal region to the cardinal margin, much more gently to the antero-lateral margins, often somewhat compressed towards the cardinal extremities; mesial sinus obscure or obsolete posteriorly, usually originating near the mid-length of the valve, rounded in the bottom and ill-defined laterally, becoming deep at the anterior margin; beak rather small and pointed, incurved, pierced by a subcircular foramen; cardinal area obsolete, the delthyrium broadly triangular.

Brachial valve more convex than the pedicle, the greatest convexity near the middle, the surface strongly convex on each side of the fold and sinus, the curvature most abrupt to the cardinal margin; mesial fold obsolete or nearly obsolete posterior to the middle, becoming strongly elevated anteriorly, rounded on top, not sharply defined laterally; beak strongly incurved.

In the usual condition of preservation, the surface of both valves is marked by more or less crowded, concentric lines of growth. When not exfoliated these growth lines are produced into lamellæ which are divided by grooves or slits into fine ribs or spines.

Remarks.—*C. incrassata* is a close ally of *C. obmaxima,* being distinguished from that species by its less transverse form, and by the more anterior position of the point of origin of the fold and sinus. It occurs commonly in the Burlington limestone, where the allied species is rarely found, and has not been observed in the Fern Glen or the Keokuk where *C. obmaxima* is most abundant. Not infrequently examples of this species are dark colored, sometimes almost black, especially in the umbonal

portion of the pedicle valve. This coloration in the fossil shell is perhaps due to some original coloration in the living shell.

Horizon.—Burlington limestone.

Cliothyridina tenuilineata (Rowley)

Plate LXXX, Figs. 1-12

1900. *Athyris tenuilineata* Rowley, Am. Geol., vol. 25, p. 264, pl. 5, figs. 31-33.

1901. *Cleiothyris hirsuta* Weller, Trans. St. Louis Acad. Sci., vol. 11, p. 187, pl. 16, figs. 25-27.

Description.—Shell small, lenticular, subcircular in outline, the length and breadth subequal, the greatest width near the mid-length of the shell, the hinge-line much shorter than the greatest width, the cardinal extremities rounded. The dimensions of two nearly perfect examples, metatypes, are: length of pedicle valve 8.9 mm. and 8 mm., length of brachial valve 8.1 mm. and 7.5 mm., greatest width 8.7 mm. and 8.7 mm., thickness 5.1 mm. and 4.8 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the cardinal margin on each side of the beak, and more gently to the lateral and anterior margins; mesial portion of the valve slightly flattened anteriorly but not depressed to form a mesial sinus; the beak rather small, sharply pointed and incurved, perforated by a subcircular foramen which encroaches upon the umbonal region of the valve; the delthyrium filled by the beak of the opposite valve.

Brachial valve subequally or a little less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins, the umbonal region rather prominent and projecting posteriorly a little beyond the hinge-line; mesial fold absent but the median portion of the valve is slightly flattened towards the front; the beak strongly incurved beneath that of the opposite valve and nearly or quite filling the delthyrium of the pedicle valve.

Surface of both valves marked by thin, closely crowded, regular, imbricating lamellæ which are divided into flattened spines, of which three or four occupy one millimeter, the spines of successive concentric rows are usually uniform in position and are consequently rather regularly arranged in radial series; when partially exfoliated the shell is marked only by the fine concentric markings.

Remarks.—This species is so closely allied to *C. hirsuta* of the higher beds of the Mississippian series that there is perhaps no justification in considering them as distinct. A careful examination of all examples available, however, seems to indicate that the concentric rows of flattened spines in this species are somewhat finer, more regular and more closely

crowded than in typical examples of *C. hirsuta.* The shell is also less apt to exhibit the slightly pentagonal outline which is commonly assumed by *C. hirsuta.*

Horizon.—Kinderhook oolite and lower Burlington white chert.

CLIOTHYRIDINA HIRSUTA (Hall)

Plate LXXX, Figs. 13-24.

1857. *Spirigera hirsuta* Hall, Trans. Albany Inst., vol. 4, p. 8.
1882. *Athyris hirsuta* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 49, pl. 6, figs. 18-21.
1883. *Athyris hirsuta* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 328, pl. 29, figs. 18-21.
1884. *Athyris hirsuta* Walcott, Pal. Eureka Dist., p. 222, pl. 18, fig. 5.
1894. *Cliothyris Roysii* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 35, fig. 9 (not fig. 10).
1895. *Cliothyris Roysii* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, fig. 23 (not fig. 24).
1895. *Cliothyris hirsuta* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, figs. 25-28.
1906. *Cleiothyris hirsuta* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1320, pl. 19, figs. 1-1a; pl. 22, figs. 18-21.

Description.—Shell small, lenticular, suborbicular, subquadrangular or subpentagonal in outline, length and breadth usually subequal, the greatest width at about the mid-length of the shell; hinge-line much shorter than the greatest width of the shell, cardinal extremities rounded, the two valves subequally convex. The dimensions of a specimen of average size are: length 9 mm., width 9.2 mm., thickness 6 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin and more gently to the lateral and anterior margins; the beak small, slightly incurved, pierced by a subcircular foramen which lies in a plane oblique to the plane of the valves; delthyrium broad, filled by the beak of the opposite valve, connected with the foramen at its apex; mesial sinus obsolete, but in some of the larger examples the mesial portion of the shell is slightly flattened.

Brachial valve nearly equally convex with the pedicle, the greatest convexity posterior to the middle, the surface curving abruptly from the point of greatest convexity to the cardinal margin, and more gently to the lateral and anterior margins; mesial fold obsolete or represented only by a narrow, median, flattened region which is more or less ill-defined laterally; beak strongly incurved beneath that of the opposite valve, and nearly or quite filling the delthyrium of that valve.

The surface markings of both valves consist of thin, crowded, concentric, closely imbricating, lamellose extensions of the shell, which

are divided into flattened spines, about three of which occupy 1 mm., the spines of successive rows are usually somewhat regularly arranged in radial series so that the surface of the shell, when not exfoliated, has the appearance of being finely costate.

Remarks.—This species exhibits considerable variation in size, although in its more typical form it rarely exceeds 10 mm. in length. The proportional dimensions of the shell are also somewhat variable, the width being sometimes greater and sometimes less than the length, though the width is more commonly equal to or a little greater than the length. The species is most common and has its most typical development in the fauna of the Salem limestone, but it occurs also in beds both higher and lower than that horizon. The species most closely resembles *C. parvirostra*, but it is smaller and usually more nearly subcircular in outline, although *C. parvirostra* has sometimes been interpreted as a large form of *C. hirsuta*. The species also resembles *C. sublamellosa*, but besides being a smaller species its valves are subequally convex, while the brachial valve of *C. sublamellosa* is notably more convex than the pedicle. It is not improbable that the young individuals of *C. sublamellosa* have more nearly equally convex valves than the mature shells, and that those individuals in the Chester which have sometimes been identified as *C. hirsuta* are in reality the young of *S. sublamellosa*.

Horizon.—Warsaw formation, Salem limestone, Ste. Genevieve limestone.

Cliothyridina lenticularis n. sp.

Plate LXXX, Figs. 25-30

Description.—Shell small, lenticular in form, subelliptical to subpentagonal in outline, the width greater than the length, the hinge-line much shorter than the greatest width of the shell. The dimensions of two individuals are: length 10 mm. and 11 mm., width 10.5 mm. and 13.3 mm., thickness 5.8 mm. and 6 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, the surface slightly compressed towards the cardinal extremities, curving rather abruptly from the point of greatest convexity to the cardinal margin and more gently to the lateral margins, in the median portion the surface of the valve curves with increasing convexity to the anterior margin; mesial sinus obsolete except towards the front of the valve, where a broad, flattened area is developed which is depressed slightly or not at all below the general surface, anteriorly this flattened area curves somewhat abruptly towards the opposite valve and is produced beyond the general outline of the valve; the beak small, a little incurved, pierced by a subcircular foramen; cardinal area obsolete, the delthyrium connecting with the foramen at its apex, filled by the beak of the opposite valve.

Brachial valve equally or a little more convex than the pedicle, greatest convexity posterior to the middle, the surface curving abruptly from the point of greatest convexity to the cardinal margin, and more gently to the anterior margin, laterally from the median line the surface is at first convex and then becomes straight or rather strongly concave, the lateral slopes of the valve being compressed, in extreme cases strongly so; the mesial fold broadly rounded, ill-defined laterally, most elevated in front, in those specimens with the lateral slopes of the valve strongly compressed the broad, ill-defined fold extends well towards the beak; beak strongly incurved, filling the delthyrium of the opposite valve.

Surface of both valves marked by crowded, concentric rows of closely imbricating, fine spines, which are usually more or less completely eroded except towards the anterior and lateral margins of the shell. These spines are in such close contact with the surface of the shell, at times, as to give it the appearance of being finely costate towards the margin.

Remarks.—This species is most closely allied to *C. hirsuta*, and perhaps might not be considered as distinct from it by some observers. It differs from that species in being proportionally much thinner, in having the broad, anterior, mesial flattening of the pedicle valve produced towards the opposite valve in front, in the compressed lateral slopes of the brachial valve, and in the finer surface spines. The species has been observed only in the St. Louis limestone, where it sometimes occurs in great numbers upon the surface of the limestone in partings between beds. The specimens are apt to be much crushed and flattened, and the true form of the shell is only occasionally found.

Horizon.—St. Louis limestone.

Cliothyridina parvirostris (Meek and Worthen)

Plate LXXVIII, Fig. 25; Plate LXXX, Figs. 61-66

1860. *Athyris parvirostra* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 451.

1866. *Athyris planosulcata ?* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 254, pl. 18, figs. 8a-d.

Description.—Shell below medium size, lenticular, subcircular to subpentagonal in outline, the length and breadth subequal, the greatest width near the mid-length of the shell. The dimensions of a nearly complete specimen are: length of pedicle valve 19 mm., length of brachial valve 18 mm., width 18.5 mm., thickness 11.5 mm.

Pedicle valve most convex near or posterior to the middle, the surface curving abruptly to the cardinal margin and more gently to the lateral and anterior margins; beak small, incurved, perforated by a small subcircular foramen which encroaches upon the umbonal portion of the

valve; delthyrium filled with the beak of the opposite valve, joined with the foramen at its apex; mesial sinus wanting, the mesial portion of the valve sometimes slightly flattened, and the anterior margin a little produced.

Brachial valve about equally convex with the pedicle, the greatest convexity near or a little posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the lateral and anterior margins; mesial fold wanting, the mesial portion of the valve sometimes slightly flattened; the beak strongly incurved beneath that of the opposite valve and nearly filling the delthyrium.

The surface of both valves marked by thin, concentric, closely imbricating, lamellar extensions which are divided into flattened spines, although, as commonly preserved, these surface characters have been removed by exfoliation.

Remarks.—This species is most closely related to *C. hirsuta* and *C. sublamellosa*. From the first of these it differs in its larger size, usually in its more subpentagonal outline, and often in the slight extension of the anterior margin of the pedicle valve, although without the development of a mesial sinus. In size the species is similar to *C. sublamellosa*, but it differs from that species in having the valves subequally convex instead of having the brachial valve notably more convex than the pedicle. The species has sometimes been referred to the European *Athyris planosulcata*, but that species differs from *C. parvirostris* and other members of the genus *Cliothyridina*, in having the concentric lamellæ of the shell entire, not divided into spines, a condition which, so far as external characters are concerned, would throw that species into the genus *Atrypa* in its strict sense. The concentric lamellæ of *A. planosulcata*, however, are distinctly ribbed, and these ribs are only one step removed from the concentric rows of spines in *Cliothyridina*. Exfoliated specimens of *A. planosulcata* and *C. parvirostris* would perhaps be indistinguishable, since the general proportions of the two shells are much alike.

Horizon.—Keokuk limestone.

Cliothyridina sublamellosa (Hall)

Plate LXXX, Figs. 31-60

1858. *Athyris sublamellosa* Hall, Geol. Iowa, vol. 1, pt. 2, p. 702, pl. 27, figs. 1a-c.
1861. *Athyris obvia* McChesney, Desc. New Spec. Foss., p. 81.
1863. *Spirigera Clintonensis* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 89.
1863. *Spirigera Americana* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 89.
1894. *Athyris sublamellosa* Keyes, Mo. Geol. Surv., vol. 5, p. 92.

1894. *Cliothyris Royssi* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 35, fig. 10 (not fig. 9).
1895. *Cliothyris Royssi* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 46, fig. 24 (not fig. 23).
1911. *Cleiothyris hirsuta* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 388, fig. 15.

Description.—Shell below medium size, usually longer than wide, the greatest width near or posterior to the mid-length, sometimes wider than long, suborbicular or subovate in outline, the hinge-line much shorter than the greatest width, both valves convex, the brachial valve usually more convex than the pedicle and sometimes notably so. The dimensions of an average specimen are: length 19.5 mm., width 20.5 mm., thickness 12 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle of the valve in the umbonal region, the surface curving abruptly from the umbonal region to the cardinal margin and gently towards the lateral and anterior margins, often compressed or even concave towards the lateral margins; beak not prominent, but slightly extended beyond that of the opposite valve, only slightly incurved, perforated by a subcircular, oblique foramen which opens into the delthyrium posteriorly; mesial sinus obsolete in smaller individuals and sometimes obscure in full grown examples, but often well developed towards the anterior margin of the valve where it is rather narrow and of moderate depth, rounded in the bottom and ill-defined laterally.

Brachial valve more convex than the pedicle, the greatest convexity posterior to the middle, the surface curving rather abruptly from the point of greatest convexity towards the cardinal margin, and more gently to the lateral and anterior margins, the convexity extending out to the lateral margins or sometimes slightly compressed laterally; the beak incurved beneath that of the opposite valve, and more or less completely filling the delthyrium; mesial fold obscure except sometimes near the anterior margin, when best developed it consists of a narrow, mesial flattened area more or less illdefined laterally, and not distinctly elevated above the general surface of the valve except sometimes near the anterior margin.

The surface markings of both valves consist of broad, thin, concentric lamellose expansions of the shell which are divided nearly to the base into flattened spines, about three of which occupy the space of one millimeter.

Remarks.—This species is one of the conspicuous members of the lower Chester faunas, and may be readily recognized on account of the greater convexity of the brachial valve. In shale beds the surface ornamentation is not infrequently more or less perfectly preserved, but in the limestones these characters are all destroyed by exfoliation in removing the speci-

mens from the matrix. The stronger development of the fold and sinus towards the anterior margin of the shell, and the concavity of the pedicle valve towards the lateral margins, are characters produced almost entirely by the development of the concentric lamellose expansions from the shell, when these are removed both of these characters largely disappear. In the original description of the species the absence of a distinct mesial sinus in the pedicle valve is mentioned, and this is true in specimens, such as are illustrated by Hall, which have for the most part lost their concentric lamellæ.

The shell described by McChesney as *Athyris obvia* is said to differ from *C. sublamellosa* in having the pedicle valve deeper than the brachial. The type of McChesney's species is lost, and in his later publications the species is not figured and is not even mentioned, suggesting that it was abandoned by the author. The species was described from the Chester limestone, but late collections have shown that no such form is commonly present in the fauna of that formation which can be considered as distinct from *C. sublamellosa,* although individuals sometimes occur having the pedicle valve most convex, a condition usually due to the distortion of the shell. It therefore seems safe to consider McChesney's species either as unrecognizable or as a synonym of *C. sublamellosa.*

The two species described from the Chester formation by Swallow as *Spirigera clintonensis* and *S. americana* are clearly synonyms of *C. sublamellosa,* although the types of the species are apparently lost and cannot be studied. The description of *S. americana* exactly fits the usual form of *C. sublamellosa,* and it is not infrequently possible to select examples having a somewhat greater width than usual which correspond closely with the description of *S. clintonensis.*

Horizon.—Ste. Genevieve limestone and Chester group.

Genus *COMPOSITA* Brown

Description.—Shells small or of medium size, subovate, subquadrangular to subpentagonal in outline, the valves biconvex, with the fold and sinus developed in the anterior portion of the shell or sometimes extending posteriorly to the umbonal region, both the fold and the sinus may be marked by a rather sharp mesial sulcus. The surface of the valves smooth or marked only by concentric lines of growth which are never extended into lamellæ. The beak of the pedicle valve incurved so as to conceal the delthyrium, but the foramen is usually exposed, encroaching upon the umbonal region of the valve. Internally the dental lamellæ and muscular scars resemble those of *Athyris,* but with the diductor impressions usually more faintly developed. In the brachial valve the hinge-plate is similar to that of *Athyris,* but with its posterior margin

extended posteriorly beyond the margin of the valve into the umbonal cavity of the opposite valve; the brachidium, including the jugum, with its accessory lamellæ similar to that of *Athyris*.

Remarks.—This genus is usually more ovate or subquadrangular than either *Athyris* or *Cliothyridina*, but its most essential differential character is found in the character of the surface markings, the lines of growth being extended into neither continuous nor fimbriate lamellæ. These shells have been commonly designated under the generic name *Seminula* since the publication of Hall and Clarke's[1] great work on the genera of Paleozoic Brachiopoda, but Buckman has shown[2] that the genotype of McCoy's *Seminula* is a shell allied to *Camarophoria*, and that the name is consequently inapplicable to this group of shells, and he has adopted the name *Composita* Brown, which was based upon shells of this type.

The members of the genus compose an assemblage of forms between which it is exceedingly difficult to draw sharp, specific lines. Those members of the genus from the middle and upper Mississippian faunas of the Mississippi valley basin are usually referred to one of two species, *C. trinuclea* or *C. subquadrata*. The first of these was originally described from the Salem limestone fauna of Indiana and Illinois, the second from the Chester fauna of Illinois. An examination of a large number of individuals from these two horizons, from both the original and other localities, shows that series can be selected which pass with complete gradation from one form to the other. Aside from these two commonly recognized forms, an extended series of specimens shows several others which if isolated would be recognized by any one as distinct specific forms, but like the two already mentioned, they merge with complete gradation into the general type. In addition to these forms the Pennsylvanian *C. subtilita* is united by regular gradations with these Mississippian shells. Under these circumstances the student is forced to one of two conclusions, he must either unite all of these forms into one exceedingly variable species, or he must recognize several specific or varietal groups which grade into each other. The last of these methods appeals most strongly to the writer, and preference is given to the recognition of the groups as of specific rank, there being little utility in giving a particular shell three names, when two will serve as well. Among a group of any considerable number of individuals of these shells, from a single horizon and locality, there is always a central form, a sort of composite of all those individuals, represented by the average of the sum total of characters, which is the true ideal of the species. It matters not that a few of the individuals agree essentially in all their characters

[1] Pal. N. Y., vol. 8, pt. 2, p. 93. (1894.)
[2] Ann. and Mag. Nat. Hist., ser. 7, vol. 18, p. 325. (1906.)

with a few individuals from another specific group from another locality and horizon. The important fact is the central, average type of shell, and as many such types as can be clearly recognized are worthy of specific recognition. The gradation of these types into each other at their extremes is indication only of the close and probable genetic relationship of the forms and probably of the youth of the generic type. With this interpretation of the genus it will not infrequently be found to be difficult or even impossible to identify specifically certain individual specimens, and specific identifications will necessarily be made from groups of individuals.

Composita trinuclea (Hall)

Plate LXXXI, Figs. 16-45

1856. *Terebratula trinuclea* Hall, Trans. Alb. Inst., vol. 4, p. 7.
1858. *Terebratula trinuclea* Hall, Geol. Iowa, vol. 1, pt. 2, p. 659, pl. 23, figs. 4a-c, 5.
1882. *Athyris trinucleus* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 50, pl. 6, figs. 22-27.
1883. *Athyris trinucleus* Hall, 12th Ann. Rep. Geol. Surv. Ind., p. 329, pl. 29, figs. 22-27.
1891. *Athyris subquadrata* Whitfield, Am. N. Y. Acad. Sci., vol. 5, p. 585, pl. 14, figs. 1-3.
1894. *Seminula trinuclea* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 35, figs. 11, 12, 14.
1894. *Seminula subquadrata* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 35, figs. 13, 15.
1894. *Athyris trinuclea* Keyes, Mo. Geol. Surv., vol. 5, p. 92.
1895. *Athyris subquadrata* Whitfield, Geol. Surv. Ohio, vol. 7, p. 472, pl. 10, figs. 1-3.
1895. *Seminula trinuclea* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 47, figs. 5, 6, 10-14.
1895. *Seminula subquadrata* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 47, figs. 7-9, 15, 16; pl. 84, figs. 30-31.
1897. *Athyris subquadrata* Weller, Trans. N. Y. Acad. Sci., vol. 16, p. 258, pl. 18, fig. 16.
1903. *Seminula subquadrata ?* Girty, U. S. Geol. Survey, Prof. Paper, No. 16, p. 296, pl. 1, fig. 5.
1906. *Seminula trinuclea* Beede, 30th Ann. Rep. Geol. Surv. Ind., p. 1322, pl. 22, figs. 22-27.
1909. *Seminula subquadrata* Bassler, Va. Geol. Surv., Bull. No. II A, pl. 29, figs. 6-8.
1909. *Seminula trinuclea* Bassler, Va. Geol. Surv., Bull. No. II A, pl. 29, figs. 9-10.
1911. *Seminula subquadrata* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 383, figs. 13a-e.

Description.—Shell usually small, always below medium size, subovate in outline, the larger specimens sometimes becoming subquadrate or subpentagonal, the width usually less than the length, but sometimes equal

to or greater than the length, the greatest width near or anterior to the mid-length of the shell, the fold and sinus usually well developed anteriorly. The dimensions of three examples from the Salem limestone are: length 8.9 mm., 13.8 mm. and 18.5 mm., width 8 mm., 12.7 mm., and 19.5 mm., thickness 6 mm., 9 mm. and 10.8 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal margin, and also in the narrower examples to the lateral margins, the curvature from the beak to the front margin becoming regularly less convex anteriorly; the mesial sinus originating at or near the beak as a narrow, flattened or slightly depressed line, anteriorly it becomes stronger, in the narrower examples it is rounded in the bottom, in the wider forms it is broader and often with a more or less distinct groove-like furrow along the median line, the lateral margins of the sinus are ill-defined, but in some examples, especially the broader ones, there is a more or less well-defined furrow upon each lateral slope of the valve, a little outside of the margin of the sinus and parallel to it, these furrows sometimes originating in the umbonal region and becoming stronger towards the anterior margin; the beak more or less strongly incurved, truncated obliquely to the plane of the valve, and perforated by a large subcircular foramen; cardinal area obsolete, the delthyrium broadly triangular, connected at its apex with the foramen, nearly or quite filled by the beak of the opposite valve.

Brachial valve somewhat trilobate, about equally convex with the pedicle, the greatest convexity usually near the middle; mesial fold usually originating in the umbonal region, only weakly developed in the posterior half of the shell, becoming more prominent in front, in the narrower forms it is rounded on top, but in the broader individuals it is flatter and is sometimes marked by a narrow, shallow, median furrow which originates near the middle of the shell and continues to the front margin, on each side of the fold in the more strongly trilobed forms there is a rounded sinus, originating near the middle of the valve and increasing in strength towards the front, the lateral slopes curving more or less abruptly to the lateral margins; beak strongly incurved beneath that of the opposite valve and nearly or quite filling the delthyrium.

The surface of both valves is marked by more or less regular concentric lines of growth which are sometimes crowded toward the front, otherwise the surface of the shell is smooth.

Remarks.—This species is an exceedingly variable one, and extreme forms, if found separate and isolated, would be considered without hesitation as distinct species. The variation in size is considerable, the smaller specimens from the diminutive Spergen Hill fauna sometimes being less than 5 mm. in length, although apparently adult individuals. The larger examples are often as much as 20 mm. in length. The propor-

tional width and thickness of the shells is also extremely variable. The diminutive individuals from the Spergen Hill fauna are apt to be more globular than the larger ones. The mesial furrow, present sometimes in both fold and sinus, is a variable character, as are also the furrows outside the lateral margins of the sinus of the pedicle valve.

A nearly related species is *C. subquadrata* from the Chester fauna, and specimens here referred to *C. trinuclea* have frequently been called *C. subquadrata*, in fact these two names have sometimes been considered as synonyms. There seems to be a constant difference between the two forms, however, in the more posterior extension of the mesial sinus of the pedicle valve in *C. trinuclea*.

Horizon.—Salem limestone, St. Louis limestone, Ste. Genevieve limestone, Chester group.

Composita lewisensis n. sp.

Plate LXXXI, Figs. 46-51

Description.—Shell small, ovate-subpentagonal in outline, longer than wide, the greatest width anterior to the mid-length. The dimensions of two nearly complete specimens are: length of pedicle valve 10.4 mm. and 10.6 mm., length of brachial valve 9.6 mm. and 9.6 mm., greatest width 9.4 mm. and 9.2 mm., thickness 6.8 mm. and 6.2 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the postero-lateral margins, becoming inflected to the cardinal extremities and curving much more gently to the antero-lateral and anterior margins; mesial sinus inconspicuous, usually originating near or in front of the middle of the valve, very shallow, rounded in the bottom, ill-defined at its lateral margins; the beak small, pointed, rather strongly incurved, perforated by a subcircular foramen which encroaches wholly upon the umbonal region of the valve; cardinal area obsolete, the delthyrium closed.

Brachial valve subequally or a little less convex than the pedicle, the greatest convexity posterior to the middle, the surface curving rather abruptly to the postero-lateral margins and more gently to the antero-lateral and anterior margins; mesial fold obsolete, the mesial portion of the valve usually obscurely flattened anteriorly from the middle, and sometimes very slightly depressed towards the front margin to form a slight sinus which is fainter and more obscure than that of the opposite valve; beak pointed, strongly incurved beneath that of the opposite valve and partially filling the delthyrium.

Surface of both valves marked by somewhat regular, concentric lines of growth which are sometimes nearly obsolete except near the anterior margin.

Remarks.—This little shell is characterized by the absence of a mesial elevation of the brachial valve, and by the slight mesial sinus of the ped-

icle valve. It resembles *C. lævis*, but besides being a somewhat thicker shell it does not possess the distinct sinus of the brachial valve and the consequent anterior emargination of that species, and the concentric lines of growth are much more conspicuous. In its surface markings the species most closely resembles *C. trinucleа*, but it may be easily distinguished from that species by the obsolete fold and slight sinus.

Locality.—Patrick's Quarry, Middle Fabius River, Lewis Co., Mo.

Composita subquadrata (Hall)

Plate LXXXI, Figs. 1-15

1858. *Athyris subquadrata* Hall, Geol. Iowa, vol. 1, pt. 2, p. 703, pl. 27, figs. 2a-d; p. 708, fig. 118.
1894. *Athyris subquadrata* Keyes, Mo. Geol. Surv., vol. 5, p. 92.

Description.—Shell of medium size, the width equal to, greater than or less than the length, subovate or subquadrate in outline, the greatest width usually a little anterior to the mid-length of the shell, the fold and sinus well developed anteriorly. The dimensions of four specimens are: length 27 mm., 25 mm., 25 mm., and 18.5 mm.; width 27.5 mm., 26.5 mm., 24.5 mm., and 19 mm.; thickness 17 mm., 17 mm., 17.5 mm., and 11.5 mm.

Pedicle valve most convex posterior to the middle, the median line arched from the beak to the front margin with a decreasing convexity anteriorly, the surface curving abruptly from the umbonal region to the cardinal margin and much more gently to the antero-lateral margins; the mesial sinus usually obsolete in the anterior half of the shell, originating near the middle of the valve as a broad, shallow, ill-defined depression, remaining broad and shallow to the front of the shell where it is more or less produced in a lingual extension, the lateral slopes on each side of the sinus convex; the beak incurved, truncated obliquely to the plane of the valve and perforated by a large, subcircular or subovate foramen; cardinal area obsolete, the delthyrium broadly triangular, nearly filled by the beak of the opposite valve.

Brachial valve more convex than the pedicle, the greatest convexity usually in front of the middle, the surface curving rather abruptly towards the cardinal margin and much more gently towards the front; mesial fold nearly or quite obsolete posteriorly, broadly rounded and more or less elevated in front, lateral slopes of the valve convex except where they curve up into the sides of the median fold; the beak strongly incurved, filling the delthyrium of the opposite valve.

Surface of both valves marked by concentric lines of growth which become more numerous and sometimes crowded towards the front of the shell.

Remarks.—This species has not infrequently been confused with *C. trinucleа*, as here interpreted, but it differs from that form in the larger size

of the mature shell, in the greater obsoleseence of the mesial sinus of the pedicle valve towards the beak, in the broader and flatter sinus anteriorly.

The species was originally described from Chester, Illinois, but the original type of the species, judging from the illustrations alone, was not an entirely typical representative as shown by the many specimens from Chester which have come under the observation of the writer. Hall's figure 2b represents a shell having the sinus originating much nearer the beak than usual, in this respect simulating *C. trinuclea,* the lateral slopes of the valves, however, do not show the distinct trilobation of the shell which is so common in that species. Examples of the Chester shell can be selected which agree almost exactly with some specimens of *C. trinuclea,* but the average characters of a large number of individuals of the two forms are quite different. The species is perhaps just as closely allied to *C. argentea* of the Pennsylvanian faunas, it is of about the same average size but usually has a somewhat flatter mesial sinus.

Horizon.—Chester group.

Composita sulcata n. sp.
Plate LXXXII, Figs. 1-10

Description.—Shell below medium size, subquadrate in outline, wider than long, the greatest width near the mid-length of the shell. The dimensions of a nearly complete specimen are: length of pedicle valve 20 mm., length of brachial valve 17.5 mm., greatest width 23.9 mm., thickness 12 mm.

Pedicle valve most convex in the umbonal region, the surface curving abruptly and becoming a little inflected to the cardinal margin, gently convex from the umbo to the antero-lateral margins; beak rather short, incurved; the mesial sinus originating at or near the beak, increasing rapidly in depth towards the front where it becomes very profound and is produced in a rounded anterior extension of the valve, it is illdefined laterally and its width in front is sometimes equal to one-half the total width of the valve, in the bottom it is rounded or subangular.

Brachial valve about as deep or a little deeper than the pedicle, its greatest depth near the middle, the surface curving somewhat abruptly from the umbo to the cardinal margin, gently convex from the umbo to the middle of the lateral margins and more strongly curved to the antero-lateral margins; along the median line the surface is convexly curved posteriorly, becoming nearly straight posterior to the middle and so continuing to the front; mesial fold little or not at all differentiated posteriorly, becoming much elevated in front, not sharply defined laterally but separated from the lateral slopes by a distinct sinuosity of the shell on each side.

Surface of the shell marked only by concentric lines of growth which are sometimes stronger and more crowded towards the outer margin of the valves.

Remarks.—This species differs from *C. subquadrata*, its nearest ally, in its much deeper sinus towards the front, a character which is more strongly developed in this species than in any other member of the genus here defined.

Horizon.—Chester group.

COMPOSITA LÆVIS n. sp.

Plate LXXXII, Figs. 14-20

Description.—Shell small, longer than wide, with the greatest width anterior to the middle, subovate in outline, with the anterior margin emarginate. The dimensions of two nearly perfect examples are: length of pedicle valve 12 mm. and 10.7 mm., length of brachial valve 11 mm. and 10 mm., greatest widtl. 10.3 mm. and 9.3 mm., thickness 7.5 mm. and 6.5 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the postero-lateral margins and strongly inflected to the cardinal extremities, the curvature much more gentle to the antero-lateral and anterior margins; mesial sinus short, originating near or a little in front of the middle, either remaining shallow or attaining a moderate width and depth at the anterior margin; the beak attenuate and moderately incurved, coming nearly in contact with the umbo of the opposite valve, truncated obliquely to the plane of the valve, the foramen rather large, elliptical in outline, encroaching entirely upon the umbonal portion of the valve, the delthyrium filled with the beak of the opposite valve.

Brachial valve subequally or a little more convex than the pedicle, the greatest convexity posterior to the middle, the umbo prominent and projecting notably posteriorly beyond the hinge-line, the surface curving abruptly to the postero-lateral margins and becoming somewhat inflected at the cardinal extremities, curving more gently to the antero-lateral and anterior margins; mesial portion of the valve somewhat flattened anteriorly from the middle, usually becoming slightly depressed in a short and shallow median sinus near the anterior margin, which, meeting the sinus of the opposite valve, produces the emargination of the shell in front; beak sharply pointed and strongly incurved beneath that of the opposite valve.

Surface of both valves nearly smooth, marked only by a few obscure, concentric lines of growth which are commonly present only towards the anterior margin.

Remarks.—This species is characterized by the prominence of the umbo of the brachial valve, the smoothness of the surface, the shortness of the mesial sinus of the pedicle valve and the absence of a mesial fold in the brachial valve, in place of which the surface of the valve is flattened towards the front and usually somewhat depressed in a slight mesial sinus close to the front margin.

Horizon.—Chester group.

Composita pentagonia n. sp.

Plate LXXXII, Figs. 52-57

Description.—Shell below medium size, broader than long, subpentagonal in outline, the postero-lateral margins longer than the other sides of the pentagon and meeting at the beak in an angle of about 105 degrees, laterally the margins are rounded, becoming a little concave antero-laterally, the anterior margin rather short and emarginate. The dimensions of two very perfect internal casts are: length of pedicle valve 15.5 mm. and 14.8 mm., length of brachial valve 14 mm. and 12.8 mm., greatest width 16.3 mm. and 16.5 mm., thickness 11 mm. and 10.3 mm.

Pedicle valve convex in the umbonal region, the surface curving abruptly as it approaches the postero-lateral margins, and in the internal casts a little incurved to the cardinal extremities, towards the antero-lateral margins the surface is regularly convex and along the median line from beak to front it describes nearly a semicircle; mesial sinus originating near the middle of the valve, shallow, of moderate width, and rounded in the bottom, laterally its surface rounds regularly into the lateral slopes of the valve so it is not sharply defined; the beak strongly incurved, the foramen apparently rather small, the delthyrium filled with the beak of the opposite valve. Internally the dental lamellæ are rather strong and reach anteriorly from the beak from one-fifth to one-fourth the length of the valve.

Brachial valve a little less convex than the pedicle, its greatest convexity near or a little posterior to the middle, the surface curving more abruptly to the postero-lateral margins, more gently to the antero-lateral and anterior margins; mesial fold originating near the middle of the valve, low, flattened on top and towards the front depressed in a slight longitudinal sinus producing the emargination of the anterior margin of the shell, laterally the fold is bounded by slight depressions more noticeable towards the front, which produce the concavity or emargination of the antero-lateral margins of the shell; the beak strongly incurved beneath that of the opposite valve.

Surface of both valves, as seen in the internal casts, marked only by rather strong, somewhat irregular, concentric lines of growth towards the front.

Remarks.—This species has been established upon two very perfect internal casts from chert, which differ so notably from other allied athyroid shells in form and general proportions that one is forced to consider them as specifically distinct. They resemble, in some degree, some of the shells referred to *Athyris ambigua* by British paleontologists, but the interpretation of this species has commonly been so broad as to include almost all species of *Composita*. In these internal casts the external surface characters are, of course, lacking, but the shells must have possessed very strong concentric lines of growth towards the front because they are so well exhibited even upon the internal casts; whether or no they also possessed other markings is not possible to determine from these specimens. When preserved with the shell present, the species could undoubtedly be recognized from its general form and proportions.

Horizon.—Residual chert, probably of Keokuk limestone.

Composita globosa n. sp.

Plate LXXXII, Figs. 21-26

Description.—Shell small, subovate in outline, narrowly truncate or slightly emarginate in front, usually a little longer than wide, but sometimes wider than long, the greatest width near the mid-length of the valve; the valves subequally convex. The dimensions of a nearly perfect specimen are: length of pedicle valve 12.5 mm., length of brachial valve 11.1 mm., greatest width 12.1 mm., thickness 8.3 mm.

Pedicle valve with its greatest depth posterior to the middle, the surface curving abruptly to the cardinal margin, and more gently to the lateral and anterior margins; the beak pointed and incurved; mesial sinus obsolete towards the beak, originating as a flattening of the valve in the umbonal region and continued to the front margin as a merely flattened band or as a very shallow sinus not very sharply defined from the lateral slopes.

Brachial valve with its greatest depth posterior to the middle, the surface curving rather abruptly to the cardinal margin and more gently to the anterior and lateral margins, not compressed towards the cardinal extremities; the median portion of the valve not differentiated from the lateral slopes posteriorly, but anteriorly it becomes flattened or slightly depressed in a shallow sinus, which, meeting the similar flattened band or sinus of the opposite valve, gives rise to the anterior truncation or emargination of the shell.

Surface of both valves nearly smooth, marked only by faint lines of growth which are sometimes crowded and more conspicuous near the outer margin of the shell.

Remarks.—This is a small species, rarely attaining a greater length than 15 mm. It is characterized by its more or less globose form, nearly

obsolete sinus of the pedicle valve, and the absence of a mesial fold in the brachial valve, in place of which the valve is flattened or slightly sinuous.

Horizon.—Keokuk limestone.

Composita opposita (White and Whitfield)

Plate LXXXII, Figs. 11-13

1862. *Rhynchonella opposita* White and Whitfield, Proc. Boston Soc. Nat. Hist., vol. 8, p. 294.

Description.—Shell very small, subtriangular in outline, broader than long, the greatest width near the anterior margin, the postero-lateral margins very long, nearly straight anteriorly, becoming slightly convex posteriorly, meeting at the beak in an angle of about 100 degrees, the anterior margin trisinuate, meeting the lateral margins in the acutely angular antero-lateral extremities of the shell. The dimensions of the holotype are: length of pedicle valve 5.5 mm., length of brachial valve 5 mm., greatest width 6 mm., thickness 3.2 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly to the cardinal extremities, less abruptly to the antero-lateral margins and gently to the anterior margin; mesial sinus originating in the umbonal region, shallow and rather narrow, rounded in the bottom, not sharply defined laterally, upon each lateral slope another sinus similar to the mesial one, but slightly shallower and narrower, originates a little in front of the point of origin of the mesial sinus, continuing to the anterior margin, these three depressions divide the entire surface of the valve anteriorly into four rounded, subequal plications; the beak incurved, pierced by a large foramen which encroaches upon the umbonal portion of the valve; the delthyrium filled by the beak of the opposite valve.

Brachial valve subequally convex with the pedicle, the greatest depth posterior to the middle, the surface curving abruptly to the cardinal extremities, less abruptly to the lateral margins anteriorly, and more gently to the anterior margin; the surface of the valve anteriorly with three shallow depressions entirely similar to those of the pedicle valve and opposite to them, the presence of the three depressions in each valve producing the three emarginations in the anterior margin; the beak strongly incurved beneath that of the opposite valve.

Surface of both valves marked by more or less obscure, regular, concentric lines of growth.

Remarks.—The only example of this species which has come under the observation of the writer is the holotype in the collection of the American Museum of Natural History in New York. The original reference of the species to the genus *Rhynchonella* is obviously incorrect, the specimen

clearly being an athyroid shell of the genus *Composita*. The species may be easily distinguished from any other member of this genus by its subtriangular form, with its greatest breadth near the front of the shell, by the acutely angular antero-lateral extremities of the shell, and by the three distinct emarginations of the front.

The exact horizon of the species can be certainly determined only by the collection of additional examples from the type locality at Burlington, Iowa. The original definition gives the horizon as "Chemung Group", which would indicate Kinderhook. The shell itself is from a limestone and its lithologic characters would suggest that it was collected from the uppermost bed of the Kinderhook at Burlington.

Horizon.—Upper Kinderhook (?).

Composita ? corpulenta (Winchell)

Plate LXXVII, Figs. 55-59

1863. *Spirigera corpulenta* Winchell, Proc. Acad. Nat. Sci. Phil., p. 6.
1900. *Athyris corpulenta* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 75, pl. 2, figs. 12-15.

Description.—Shell of medium size or smaller, subglobose in form, longer than wide, the width and thickness subequal, longitudinally subelliptical in outline, the greatest width near the mid-length of the shell, the hinge-line very short, the cardinal extremities rounded. The dimensions of a nearly perfect specimen are: length 17 mm., width 13.5 mm., thickness 13 mm.

Pedicle valve strongly convex or ventricose, the greatest convexity near or a little posterior to the middle, the surface curving abruptly in all directions from the point of greatest convexity; the beak contiguous with that of the opposite valve, with no indication of a foramen in any of the specimens examined; no cardinal area developed and the characters of the delthyrium not shown in any of the specimens; mesial sinus obscure or obsolete, when present consisting usually of a mere flattening of the surface along the median line originating near the middle of the valve, which sometimes becomes slightly concave anteriorly.

Brachial valve a little less convex than the pedicle, the point of greatest convexity near or posterior to the middle, the surface curving steeply from the highest point to the posterior and lateral margins, and more gently to the anterior margin; the beak incurved beneath that of the opposite valve; the mesial fold not differentiated.

Surface of both valves marked by concentric lines of growth which are crowded at intervals.

Remarks.—The generic relations of this species are not clearly established. The species has been observed only in a fine-grained sandstone in such condition of preservation that the internal characters cannot be

determined. In its external characters the species most closely resembles the Silurian *Hindella umbonata* (Bill.), from Anticosti, but that genus has not been recognized outside of Anticosti and it is not likely that this Kinderhook form is congeneric with that very much earlier species, especially in view of the fact that the genus has not been recognized anywhere in the intervening faunas. In one specimen observed, the posterior portion of the shell is in the condition of an internal cast, and the median portion of the brachial valve appears as a ridge running to a point under the beak of the opposite valve, this condition being entirely similar to that in the internal casts of undoubted athyroid shells, this ridge being the cast of the canal which passes to the perforation through the hinge-plate. The original reference of the species to the genus *Spirigera* was essentially a reference to *Athyris*, but the contour of the shell is more nearly like members of the genus *Composita*, except in the close approximation of the beaks of the two valves, and the species is therefore placed in that genus.

Horizon.—Chonopectus sandstone of the Kinderhook.

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